Annexes to the study 'Lessons learned to inform integrated approaches for the renovation and modernisation of the built environment'

ENER/C3/2019-468/03

Written by:
Buildings Performance Institute Europe ASBL (BPIE),
CLIMACT SA,
Creara Consultores SL, and
Ecologic Institute

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Contact: B.3

E-mail: ENER-BUILDINGS@*ec.europa.eu*

European Commission
B-1049 Brussels

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Lessons learned to inform integrated approaches for the renovation and modernisation of the built environment

Annex I: Scoping and key challenges

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1. Introduction and methodology

The amending Energy Performance of Buildings Directive[1] (EPBD) introduces new elements and provisions that go beyond energy efficiency in buildings and are relevant to other related 'strategic areas'. In its call for tender, the Directorate-General for Energy (DG Energy) identified these areas as:

1. Clean and sustainable mobility
2. Digital technology
3. District approaches
4. Engaging transformation and phasing out inefficient buildings
5. Financing renovation
6. Built environment sustainability and adaptation to climate change
7. Health and well-being

The objective with Activity 1.1 was to check whether the seven strategic areas listed above are complete, or if the revised EPBD has a significant impact also on any additional strategic areas not included on the list above presented above.

To screen for potential additional areas, the Consortium prioritised reviewing EU documents relevant to the building sector, released after the publication of the call for tender, to ensure that any new element was included.

The key findings of the screening are presented in section 2, and suggestion of how to address the gaps are presented in section 3.

2. Screening of areas

Under the Clean Energy for all Europeans package, the EPBD was revised and its scope enlarged to cover new areas related to energy performance of buildings, for example, e-mobility and smartness of buildings. In addition, the EU long term vision for a prosperous, modern and competitive climate neutral economy[2], made clear that reducing emissions in the building sector is crucial for climate neutrality and that an integrated approach built on interactions and synergies across different areas is needed.

Following these developments, seven strategic areas were identified to be researched as part of this 'Lessons Learned' project. This research aims to distil best practice and identify promising integrated approaches to renovating and modernising buildings. To ensure the research has a solid grounding, our first task was to investigate whether the seven strategic areas are exhaustive or if there are possible gaps and scope to add more areas.

A new European Commission took office on 1 December 2020, after the call for tender was published. The new Commission has new priorities that were not established when the call for tender was drafted. To make sure the Lessons Learned project remains relevant and can contribute to the new Commission's objectives, the Consortium decided to check for missing strategic areas by focusing on official EU documents relevant to the building sector that the new Commission had adopted. These are detailed below. We have only listed

[1] Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency.

[2] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A Clean Planet for all: A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy, COM(2018) 773 final.

recent documents, although our scanning was more extensive, and older documents did feed into our work.

The Commission Recommendation on building modernisation[3], which offers guidelines on implementing the EPBD, was also published after the call for tender. We also reviewed it to assess whether new strategic areas should be added to the existing seven (see below).

While we have not listed the first Commission Recommendation on building renovation[4] below, it is another key EU official document we scanned.

2.1. European Green Deal

The European Green Deal (EGD)[5] is one of the new European Commission's flagship initiatives. Its key objectives are to ensure the EU can tackle climate and environmental challenges, while ensuring a prosperous and fair society that protects the health and well-being of its citizens. In addition to having a section devoted to buildings, the EGD has several objectives that are clearly linked and have an impact on building renovations.

The table below lists selected EGD priority areas, describes how these impact on building renovations, and indicates whether they are already covered under the seven strategic areas.

EGD SELECTED PRIORITIES	IMPACT ON BUILDING RENOVATIONS	COVERED/NOT COVERED
Increasing the EU's climate ambition for 2030 and 2050.	EU climate neutrality objective will require a climate-neutral building stock.	Actions and measures in all strategic areas contribute to achievement of this overall long-term objective.
	EU strategy on adaptation to climate change is likely to address climate adaptation in the building sector.	Covered by strategic area 6.
Supplying clean, affordable and secure energy.	Decarbonisation of the energy system mainly through renewable energy will require increased penetration of renewables in the building sector.	Not explicitly covered in the strategic areas but already addressed under the EPBD (Annex I), and considered as a cross-cutting issue.
	Reducing energy poverty.	Covered by strategic areas 5 and 7.
	Smart infrastructure enabling sector integration.	Covered by strategic area 2.
Mobilising industry for a clean and circular economy.	Achieving circular economy in all sectors, including the construction sector.	Covered by strategic area 6.
Building and renovating in an energy- and resource-efficient way.	Engaging in a 'renovation wave' of public and private buildings.	Covered by strategic area 4.
	Circularity of building material, including through a	Covered by strategic area 6.

[3] Commission Recommendation (EU) 2019/1019 of 7 June 2019 on building modernisation.
[4] Commission Recommendation (EU) 2019/786 of 8 May 2019 on building renovation.
[5] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. The European Green Deal, COM(2019) 640 final.

	revision of the Construction Products Regulation.	
Accelerating the shift to sustainable and smart mobility.	Automated and connected multimodal mobility.	Covered by strategic area 1.
	Measures to address emissions, urban congestion, and improved public transport.	Covered by strategic area 1.
Pursuing green finance and investment and ensuring a just transition.	Ensuring investment to finance the clean transition, including through a Sustainable Europe Investment Plan.	Covered by strategic area 5.
Mobilising research and fostering innovation.	New technologies, sustainable solutions and disruptive innovation are critical to achieve the objectives of the EGD.	Not explicitly covered in the strategic areas, but research and innovation is a cross-cutting issue.
Activating education and training.	Re-skilling and upskilling of workers to participate in the job market during the energy transition.	Not explicitly covered in the strategic areas, but it is a cross-cutting issue.

Table 1: EGD's relevant priority areas and how they are addressed in the project

2.2 The Sustainable Europe Investment Plan

On 14 January 2020, the European Commission presented the European Green Deal Investment Plan, also referred to as the Sustainable Europe Investment Plan (SEIP)[6]. This is the investment pillar of the Green Deal. The SEIP acknowledges that the transition to a climate-neutral and sustainable economy will require significant investment. To achieve the EU's 2030 climate and energy targets, it estimates that an additional EUR 260 billion per year is needed.

The table below lists selected SEIP priority areas, describes how these impact on building renovations, and indicates whether they are already covered under the seven strategic areas.

SEIP SELECTED PRIORITIES	IMPACT ON BUILDING RENOVATIONS	COVERED/NOT COVERED
Mobilising sustainable investment from all sources.	The EU budget and EU funds will increasingly finance activities that contribute to climate neutrality and some of these resources will also be accessible for building renovations.	Covered by strategic area 5.
Aid to improve energy efficiency for buildings.	Member States will have more flexibility to support upgrades that address both the energy efficiency of	Covered by strategic area 5.

[6] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Sustainable Europe Investment Plan (European Green Deal Investment Plan), 14 January 2020, COM(2020) 21 final.

	buildings and invest in renewable energy generation for self-consumption.	

Table 2: SEIP's relevant priority areas and how they are addressed in the project

2.3 Circular Economy Action Plan

On 11 March 2020, the European Commission released a new Circular Economy Action Plan[7] (CEAP). This is one of the building blocks of the European Green Deal as it will contribute to putting the EU's economy on the path to becoming fully resource-efficient and circular. Making sure circular economy principles and resource efficiency are applied to buildings and the construction sector is crucial to curb emissions and resource use.

The table below lists selected CEAP priority areas, describes how these impact on building renovations, and indicates whether they are already covered under the seven strategic areas.

CEAP SELECTED PRIORITIES	IMPACT ON BUILDING RENOVATIONS	COVERED/NOT COVERED
Construction and buildings.	Addressing the sustainability performance of construction products.	Covered by strategic area 6.
	Promoting measures to improve the durability and adaptability of built assets in line with the circular economy principles for building design.	Covered by strategic area 6.

Table 3: CEAP's relevant priority areas and how they are addressed in the project

2.4 A New Industrial Strategy for Europe

On 10 March 2020, the European Commission published a New Industrial Strategy for Europe[8]. It aims to support EU industry to remain globally competitive and lead on the transitions towards climate neutrality and digital leadership.

The table below lists selected priority areas in the communication, describes how these impact on building renovations, and indicates whether they are already covered under the seven strategic areas.

NEW INDUSTRIAL STRATEGY SELECTED PRIORITIES	IMPACT ON BUILDING RENOVATIONS	COVERED/NOT COVERED

7 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A New Circular Economy Action Plan For a Cleaner and More Competitive Europe, COM(2020) 98 final.

8 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A New Industrial Strategy for Europe, 10 March 2020, COM(2020) 102 final.

Supporting industry towards climate neutrality.	Addressing the sustainability of construction products and improving the energy efficiency and environmental performance of built assets.	Covered by strategic area 6.
Embedding a spirit of industrial innovation.	Scaling up innovative ideas, which could mean developing strategies to foster industrialised energy renovations.	Covered by strategic area 4.
Skilling and reskilling.	Finding the right skills for the digital and ecological transition.	Not explicitly covered in the strategic areas, but improving workforce skills is a cross-cutting issue.

Table 4: New Industrial Strategy's relevant priority areas and how they are addressed in the project

2.5 Shaping Europe's digital future

On 19 February 2020, the European Commission published a new communication on Shaping Europe's digital future[9]. It aims to ensure that digital transformation benefits people, supports a competitive economy and enables an open and sustainable society.

The table below lists selected priority areas in the communication, describes how these impact on building renovations, and indicates whether they are already covered under the seven strategic areas.

SHAPING EUROPE'S DIGITAL FUTURE SELECTED PRIORITIES	IMPACT ON BUILDING RENOVATIONS	COVERED/NOT COVERED
Technology that works for people.	Connectivity, including investing in smart energy infrastructure.	Covered by strategic area 2.
	Improving digital skills.	Not explicitly covered in the strategic areas but improving digital skills is a cross-cutting issue and digitalisation is already in the scope of the EPBD.
A fair and competitive economy.	Data needs to be widely and easily available, easily accessible, and simple to use and process. This could also include improving the collection and availability of building data.	Covered by strategic area 2.
An open, democratic and sustainable society.	Digital tools as powerful enablers for the sustainability transition and supporting the decarbonisation of all sectors.	Covered by strategic area 2.

[9] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Shaping Europe's digital future, 19 February 2020, COM(2020) 67 final.

Table 5: Shaping Europe's digital future's relevant priority areas and how they are addressed in the project

2.6 Commission Recommendation on building modernisation

On 7 June 2019, the European Commission published its second recommendation to support Member States to implement the EPBD[10]. It provides guidelines for implementing the provisions of the EPBD in several areas, including technical building systems and electromobility.

These areas are in the scope of the EPBD and are covered by the strategic areas selected for the study, as shown below.

COM. RECOMMENDATION SELECTED PRIORITIES	IMPACT ON BUILDING RENOVATIONS	COVERED/NOT COVERED
Technical building systems.	New requirements related to the installation of self-regulating devices and building automation and control systems in buildings that meet specific conditions.	Covered by strategic areas 2 and 4.
Electromobility.	Charging requirements in buildings.	Covered by strategic area 1.
Primary Energy Factors (PEFs).	Increasing transparency in calculating PEFs; may in the long-term increase comparability of energy performance calculation and energy performance certificates (EPC); helps to address the role of both the building envelope and on-site/off-site renewable energy sources.	Covered by strategic area 3 and 4 (role of renewables).

Table 6: Second Commission Recommendation on EPBD implementation's relevant priority areas and how they are addressed in the project

3. Addressing gaps

Our assessment confirms that the seven strategic areas listed in the call for tender appropriately cover the key areas with a crucial impact on building renovations.

However, after an in-depth scan of relevant communications issued by the new European Commission, we would like to highlight the following issues:

1. Renewable energy: To ensure the EU becomes a climate-neutral economy by 2050, renewable energy, both in electricity and in heating and cooling, must be mainstreamed.
2. Skilling and re-skilling the workforce: Improving the skills of the construction workforce in energy efficient renovation and digitalisation is crucial for the

[10] Commission Recommendation (EU) 2019/1019 of 7 June 2019 on building modernisation.

decarbonisation of the building sector. It is also important in light of general workforce shortages in sectors related to renovation in some Member States.

3. Research and innovation: New technologies and disruptive innovation can contribute to and enable building renovations.

As these three areas are cross-cutting, the Consortium does not suggest adding them to the seven strategic areas. Instead, we recommend mainstreaming and addressing the three across the relevant existing strategic areas.

We will look at renewable energy penetration in the following strategic areas:

- Clean and sustainable mobility: The research will explore sector coupling between buildings and transport, including how this can maximise renewable energy penetration.
- District approaches: The research will highlight best practice that facilitates joint planning of energy efficiency and renewable energy at the local level.
- Engaging transformation: The research will address how renewable heat in buildings can contribute to the decarbonisation of the EU's building stock.

We will look at skilling and re-skilling of the workforce in:

- Digitalisation: The research will explore how the building supply chain can benefit from digitalisation and investigate best practice to help the workforce acquire digital skills.
- Engaging transformation: The research will highlight best practice to improve the workforce's qualifications in relation to innovative renovation technologies.

Research and innovation can in principle be considered in all strategic areas. Therefore, as the overall goal of this project is to distil best practice, we will make sure to highlight best practice that involves innovative practices, including innovative business models and financing tools.

4. Conclusions

Activity 1.1 of the project aimed to identify possible gaps in the seven strategic areas listed in the call for tender. To ensure that the Lessons Learned project is useful and matches the agenda of the new European Commission, the consortium decided to screen the von der Leyen Commission's newly published initiatives to identify possible gaps. We identified renewable energy penetration, skilling the workforce and research and innovation as areas that could be further highlighted in the description of the seven strategic areas. However, as these three areas are cross-cutting, the Consortium has proposed to address them within the relevant existing strategic areas to ensure they are well covered without substantially changing the project architecture.

Activity 1.2: Strategic areas: Scope clarification

1. Introduction and methodology

The amending Energy Performance of Buildings Directive (EPBD) introduces a series of new elements and provisions that go beyond energy efficiency in buildings strictly speaking and are relevant for other related areas. Those are called "Strategic areas" and were identified by DG Energy in its call for tender as follow:

1. Clean and sustainable mobility
2. Digital technology
3. District approaches
4. Engaging transformation and phasing out inefficient buildings
5. Financing renovation
6. Built environment sustainability and adaptation to climate change
7. Health and well-being

The objective of Activity 1.2 was to clarify the scope of the seven strategic areas, by summarising the EU's goals and enabling framework for each area, describing the key trends and drivers in each area, and examining the interactions between the areas.

To do this, the Consortium reviewed the relevant EU legislation and initiatives. We also reviewed at least three recent and highly regarded reports for each area. The list of the reports we reviewed can be found in the bibliography. We used the same reports to put together the key EU challenges (Activity 1.3).

2. Clarifying the scope of each strategic area

The call for tender identified seven strategic areas and provided a short description of each. Below we give a more in-depth description of each area. We provide information on the relevant EU framework, key trends and drivers, and how policy and measures in the area contribute to achieving the overall objectives for the building sector, particularly the EPBD requirement for Member States to adopt long-term renovation strategies to achieve highly efficient and decarbonised building stock by 2050 (Art.2a).

2.1 Clean and sustainable mobility

Overview of strategic area: The transport sector is a large and still increasing source of greenhouse gas (GHG) emissions and air pollutants. Car- and lorry-based mobility also has negative impacts on safety, space distribution and quality of life. Better urban design and planning can contribute to more sustainable transport options, including by helping to reduce car travel, shortening daily travel distances, and ensuring that new settlements are public transport-oriented. Building design can also facilitate more sustainable transportation by, for example, providing charging infrastructure for electric vehicles or bike parking, including for cargo bikes.

Key trends and drivers:

- Increasing GHG emissions and worsening air pollution, particularly in cities, are a crucial driver for sustainable mobility.
- Transport volumes are rising throughout the EU, with fossil fuel-based motorised road transport driving most of this increase. The rise is partly the result of further globalisation: both people and products are travelling ever longer distances.
- Advances in battery technology will increase the penetration of electric vehicles. This will require fast adaptation of urban spaces and buildings to support charging infrastructure. Electromobility will cut emissions and air pollutants but will not solve congestion and space allocation problems.

- Increasing urbanisation is exacerbating problems including poorly functioning urban transport systems, traffic congestion and longer commuting times.
- The need to optimise the scarce space in cities underlines the benefits of boosting public transport, cycling, cargo bikes, electric scooters, car sharing, and walking compared to private car use and ownership.
- Advances in digital technology, such as video conferencing, shared mobility and automation, will reduce the need for transport. Digitalisation will also allow the connection of different mobility options and make them more efficient.

Description of EU framework: The EU approach to addressing transport's climate and environmental impacts is based on improving efficiency of vehicles, using alternative fuels, and shifting to sustainable means of transport and new mobility patterns.

When it comes to the link between transport policy and buildings, the most relevant policies and initiatives are listed below:

- The EPBD sets minimum requirements for charging infrastructure in car parks over a certain size, plus requirements for minimum infrastructure in smaller buildings.
- The Directive on alternative fuels infrastructure[11] establishes a common framework of measures for the deployment of alternative fuels infrastructure in the EU, including recharging points for electric vehicles.
- The Urban Mobility Package[12] provides guidance and financial support for sustainable mobility in urban areas. It also promotes sustainable urban mobility plans, which should embed action on mobility into a wider urban and territorial strategy.
- The EU provides financial support to local governments, researchers and companies mainly through the European Regional Development Fund, the Cohesion Fund, the Connecting Europe Facility and Horizon 2020.

Impact on overall targets for the EU building sector: Sustainable mobility has a moderate impact on the EPBD's key objectives such as achieving a highly energy-efficient and decarbonised building stock by 2050. On the other hand, the relevance of buildings for shifting to clean mobility is more pronounced. This is because buildings, including their location and urban planning more broadly, and their ability to support electromobility, can help shift towards sustainable mobility.

2.2 Digital technology

Overview of strategic area: Digital technologies can be used across the life cycle of buildings, from design and construction to people using buildings. Digitalisation is a key enabler of the decarbonisation of building stock. Firstly, it has great potential to increase the quality and scalability of energy efficiency solutions, with optimal design (for example, building information modelling, drones and 3D printing), execution (for example, digital collaboration platforms), and use of buildings (for example, automated management systems, controllable devices and smart appliances, and data collection). Secondly, it gives building users smart and flexible energy services, allowing the development of demand-side management strategies that help further integrate variable and decentralised renewable energy sources into the energy system.

Key trends and drivers:

[11] Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure.

[12] https://ec.europa.eu/transport/themes/clean-transport-urban-transport/urban-mobility/urban-mobility-package_en

- The Internet of Things has seen a general boom, with an increasing number of appliances and services connected to the Internet. This allows remote management, including in the building sector.
- Many cities have developed local energy plans with the aim, among others, of organising energy supply in a smart and sustainable, yet secure, way, for example by creating smart grids.
- Growing integration of renewables into the system means matching production with consumption cannot be done solely on the production side. The demand side is increasingly contributing to the flexibility effort.

Description of EU framework:

- The EPBD touches on areas related to digitalisation. For example, it mentions creating smart readiness indicators to rate the readiness of a building to interact with the grid and to adapt its operation to the occupants' needs (Article 8 and Annex Ia).
- The communication on Shaping Europe's digital future[13] highlights that digital tools are powerful enablers in transitioning to sustainability and can support the decarbonisation of all sectors, including the building sector.
- Data on energy consumption and production, including data on the users of buildings, are private. Therefore, they should be processed in compliance with the General Data Protection Regulation[14].
- The Commission's communication on a European strategy for data[15] details its aim to create a single market for EU data. It also announced the creation of a 'Common European energy data space' to promote availability and sharing of data to support the energy system's decarbonisation, while maintaining a customer-centric approach.
- The EU Cybersecurity Act[16] establishes an EU-wide cybersecurity certification framework for digital products, services and processes. It is expected to enhance citizens' trust when it comes to installing digital solutions in their homes and provides a competitive EU-wide framework for providers to make implementing solutions easier.

Impact on overall targets for the EU building sector:

- Digitalisation helps optimise energy use, reduce energy bills and open the way for new business models which reap the potential of digital technologies to facilitate the low-carbon transition.
- Digitalisation is a key enabler for harvesting buildings' flexibility, which allows the integration of more low-carbon variable energy sources.
- Industrialised solutions enabled by digital technologies will help reduce the waste generated by the renovation sector.
- Digitalisation in the building sector also allows better access to and collection of relevant data, including energy data.

[13] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions,. Shaping Europe's digital future. COM(2020) 67 final.

[14] Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation).

[15] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A European strategy for data, 19 February 2020 COM(2020) 66 final.

[16] Regulation (EU) 2019/881 of the European Parliament and of the Council of 17 April 2019 on ENISA (the EU Agency for Cybersecurity) and on information and communications technology cybersecurity certification and repealing Regulation (EU) No 526/2013 (Cybersecurity Act).

2.3 District approaches

Overview of strategic area: Building renovations can be planned and organised by adopting a comprehensive approach that aims to renovate not only single buildings, but rather a district or neighbourhood all at the same time. Renovations at the district level can lead to potentially significant cost savings through economy of scale and smart logistics. They can also be more attractive to investors thanks to project aggregation and distributed risk portfolios. Moreover, this approach fosters synergies between energy efficiency and other transformation in the district, including development of local renewable energy sources and urban development strategies. District approaches have the potential to lead to optimal solutions at macro level, combining energy efficiency with multiple benefits and ensuring consistent sustainable development of cities and territories.

Key trends and drivers:

- Increasing citizen participation and emerging citizen-centric strategies maximise the acceptance of (local) policy objectives and will help to trigger the planification of renovation projects at the neighbourhood level.
- The challenge of reaching high energy efficiency for certain buildings combined with the continuous penetration of renewable energy technologies fosters increasing joint consideration of energy efficiency and renewable energies to reach carbon neutrality in a smart way. District approaches contribute to maximising the synergies between energy efficiency and renewable energy, taking advantage of the potential of local renewable energy sources.
- Industrialisation and streamlining of renovation processes and solutions need to become mainstream, with the expected volume, quality and cost thresholds. District approaches can trigger projects of the required size to unlock innovations.

Description of EU framework:

- In the next review of the EPBD, Article 19 requires the European Commission to "examine in what manner Member States could apply integrated district or neighbourhood approaches in Union building and energy efficiency policy, while ensuring that each building meets the minimum energy performance requirements, for example by means of overall renovation schemes applying to a number of buildings in a spatial context instead of a single building".
- The European Green Deal[17], particularly the 'renovation wave' initiative, mentions the need to better organise renovation efforts into larger blocks to benefit from better financing conditions and economies of scale.
- The Renewable Energy Directive[18] introduces the right for individuals to self-generate, consume, store and sell excess renewable electricity to the grid at least at the market value. It also introduces the concept of the 'renewable energy community'. These communities are entitled to produce, consume, store and sell renewable energy, including through renewable power purchase agreements. These provisions create the enabling conditions and legal rights to produce and consume renewables at the district level.
- The new European Union Framework Programme for Research and Innovation, Horizon Europe[19], which will run from 2021 to 2027, has 'climate-neutral and smart cities' as one of its core missions. This clearly shows the need to identify workable approaches and solutions to decarbonise cities, moving beyond the approach of reducing energy and emissions only at the building level.

[17] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. The European Green Deal, COM(2019) 640 final.

[18] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources.

[19] https://ec.europa.eu/info/horizon-europe-next-research-and-innovation-framework-programme_en

Impact on overall targets for the EU building sector: District approaches to renovation directly contribute to achieving a highly energy-efficient and decarbonised building stock by accelerating renovation initiatives through unlocking important renovation volumes. District approaches make it possible to seize new renovation opportunities that, for financial and technological reasons, may not be available for small-scale projects.

2.4 Engaging transformation and phasing out inefficient buildings

Overview of strategic area: To ensure building stock is fully decarbonised, it is important to develop processes that fully engage end-users and consider occupants' needs. Going beyond providing just technical solutions and engaging consumers in driving change is the only way to create transformative change. This includes supporting consumers with tailored advice for renovations through one-stop-shops or building renovations passports.

In addition, a dedicated framework is necessary to improve the worst performing buildings, which are often left unrenovated because of the market, regulatory failures and other barriers. Setting mandatory minimum performance requirements at a transaction point, such as sale or rental, can have a significant impact on increasing the rate of building renovation, as owners and landlords are compelled to invest in upgrading their properties, shifting poorly performing buildings towards better performance. Mandatory minimum performance requirements are also one of the most effective means for tackling split incentives and related barriers to energy efficiency investments in multi-apartment buildings in the EU. Any building policy needs to be well-tailored to specific building segments/building types. For example, heritage buildings cannot easily fulfil all deep energy renovation requirements. To reflect their heritage value, they are often exempt under current building policies.

Key trends and drivers:
- Non-energy considerations are increasingly driving building renovations, such as improving comfort and well-being and reducing energy poverty. There is also increasing recognition that renovations can boost the construction sector and are an opportunity to support SMEs and local jobs.
- Digitalisation plays a key part in innovative approaches to building renovations with citizens at their centre. For example, digitalisation enables industrialised renovation processes that reduce renovation hassle for occupants of buildings. It also enables the collection of building data so that renovation measures can to be tailored to building occupants.
- Citizens are increasingly aware of energy and are becoming active players in the energy system (prosumers). This may help address non-market barriers to renovations, such as lack of information, and can influence behavioural change.

Description of EU framework:
- The EPBD is the key legislation setting rules for improving energy performance of buildings in the EU. It includes the long-term objective for Member States to achieve a highly energy-efficient and decarbonised building stock by 2050, and facilitate the cost-effective transformation of existing buildings into nearly zero-energy buildings. It also requires Member States to put in place policies and actions to target the worst performing segments of their national building stock.
- The Energy Efficiency Directive[20] requires that when Member States design policy measures to fulfil their obligations under Article 7 ('Energy savings obligations'), they must prioritise implementing a certain share of measures in 'vulnerable households', including those affected by energy poverty and, where appropriate, in social housing.

[20] Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency.

Impact on overall targets for the EU building sector: This strategic area is at the core of achieving a decarbonised building stock in the EU.

2.5. Financing renovation

Overview of strategic area: Availability of financing and appropriate financing tools are essential to increase the rate and depth of building renovations. Public finance alone cannot support this effort and must be used to leverage additional private investment. Innovative financing schemes and business models are emerging to maximise the effectiveness of funds, as well as to target specific market failures for renovations or more vulnerable groups of citizens.

Key trends and drivers:

- As public funds are limited, it is increasingly necessary to unlock private resources to finance building renovations. To do so, public funds are increasingly used as a guarantee to reduce the risk for private investors. The use of grants is decreasing and mainly used to target vulnerable consumers.
- Innovative financial mechanisms for building renovations are emerging, including on-tax, on-bill financing and green bonds.
- The development of technical assistance to create a pipeline of bankable projects is crucial to mobilise financing.

Description of EU framework:

- The EPBD requires Member States to adopt long-term renovation strategies to make their building stock highly efficient and decarbonised by 2050. A solid financial component must underpin these to ensure the mobilisation of investment for renovations.
- The Smart Finance for Smart Buildings Initiative aims to mobilise private investment in building renovations by using EU resources as a guarantee, thus helping de-risk investments in the building sector.
- European Local ENergy Assistance (ELENA)[21], implemented by the European Investment Bank (EIB), provides technical assistance to the public and private sector for energy efficiency and renewable energy investments in buildings.
- Several EU funds can support building renovations, including the Cohesion Fund and the European Regional Development Fund. Horizon 2020, the biggest EU research and innovation programme, also supports energy-efficient technologies and solutions for buildings, including heating and cooling.
- Alongside its new energy lending policy[22], the EIB launched the European Initiative for Building Renovations to support new ways to attract finance for building retrofits.
- The proposed European recovery package presents considerable new financing opportunities to accelerate the decarbonisation of building stock. Particularly significant are the enhanced InvestEU and the possibility of Member States being able to use funds from the Recovery and Resilience Facility for building renovations, in line with identified priorities under the European Semester and National Energy and Climate Plans.

Impact on overall targets for the EU building sector: The availability of financing is a pre-requisite to carry out building renovations. The more resources, and the more accessible they are to target specific needs, the quicker the decarbonisation of the EU building stock will happen.

[21] https://www.eib.org/en/products/advising/elena/index.htm
[22] EIB energy lending policy, available at https://www.eib.org/en/publications/eib-energy-lending-policy.htm#

2.6 Built environment sustainability and adaptation to climate change

2.6.a BUILT ENVIRONMMENT SUSTAINABILITY

Overview of strategic area: As building stock will undergo substantial renovation in the coming years, material use, and embodied emissions, are set to increase (materials and construction already account for around 15% of total lifecycle CO_2 emissions from EU buildings). In a whole lifecycle approach based on a circular economy, a low carbon building optimises the use of resources and so limits carbon emissions during construction, use and end-of-life. Building circularity depends on building design, material choice and composition, and transparent documentation of building parts. Additional circular economy measures will also be key to keep emissions in check, such as extending building lifetimes/ conservation, reducing construction and demolition waste, reusing structural building components, secondary material use and cement recycling.

Key trends and drivers:
- Urbanisation, population growth and increasing per capita floor space are contributing to increases in building space, land use for construction purposes and the amount of construction materials used, with associated embodied emissions.
- Technological and business model innovation supports the application of circular economy principles in the building sector, including, for example, the use of lightweight alternative and secondary materials.

Description of EU framework: The EPBD only addresses reducing buildings' energy use and emissions during its use phase, not its whole lifecycle. However, other legislation and initiatives cover this, particularly:
- The new Circular Economy Action Plan[23] recognises that applying circular economy principles and resource efficiency to buildings and the construction sector is crucial to curb emissions and resource use. It also announced that in 2021 the Commission will launch a new Strategy for a Sustainable Built Environment.
- The Waste Framework Directive[24] stipulates that Member States should take measures to reuse, recycle or recover at least 70% of non-hazardous construction and demolition waste by 2020.
- Level(s)'[25] guide to a new reporting framework for sustainability performance of buildings includes indicators for circularity (for example, lifespan and deconstruction materials available for recycling) and for GHG emissions along buildings' lifecycles.

Impact on overall targets for the EU building sector: EU targets for the building sector focus principally on reducing energy use and emissions in the use-phase of buildings.
From a circular economy perspective, there may be (i) synergies and (ii) trade-offs between materials and energy efficiency because on one hand (i) circular design can help reduce energy needs, but on the other (ii) components that improve energy efficiency can also increase material use and thus embodied emissions.

2.6.b ADAPTATION

Overview of strategic area: Buildings are long-lasting assets that rarely undergo renovations. That's why when a retrofit takes place it should also make buildings more resilient to the effects of climate change. The main climate hazards buildings face are extreme precipitation, heatwaves, heavy snowfall and rising sea levels. These will affect

[23] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A new Circular Economy Action Plan For a cleaner and more competitive Europe, COM(2020) 98 final.
[24] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives.
[25] https://ec.europa.eu/environment/eussd/buildings.htm

buildings differently depending on their design and location. Adaptation solutions for buildings focus on technical measures such as shading devices, planning adjustments such as building design and orientation, and nature-based solutions such as green roofs, walls or facades, which can regulate temperature variability as well as buffer precipitation peaks. It should also be noted that technologies installed in buildings to reduce emissions can be vulnerable to climate impacts. For example, solar PV are vulnerable to extreme weather events such as hail and high-speed winds. It is worth assessing the possible impacts of climate change on these technologies and identifying adaptation options.

Key trends and drivers:

- Increasing urbanisation and population are boosting construction and the replacement of green spaces with hard, impermeable surfaces. Expanding urban sprawl is also pushing settlements into at-risk, flood-prone areas.
- Increasing concerns and awareness about climate risks are driving a shift from solely focusing on building materials and energy performance to mainstreaming green solutions that can simultaneously contribute to adaptation, mitigation, biodiversity conservation, and health and well-being.
- The insurance sector is likely to play an important role in mainstreaming climate-resilient buildings. Innovative insurance products can help prevent damage but can also contribute to better reconstruction after extreme weather ('build back better').

Description of EU framework:

- The EU Adaptation Strategy[26] refers to buildings in its accompanying document 'Adapting infrastructure to climate change[27]'. It recommends considering climate resilience in EU infrastructure investment policies and in construction standards.
- The Green Paper on the insurance of natural and man-made disasters[28] highlights that insurance can play a role, together with building restrictions, in managing damage to buildings caused by extreme weather events.

Impact on overall targets for the EU building sector: The area of adaptation to climate change has limited impact on the EPBD's targets. However, passive solutions and energy efficiency measures are becoming increasingly important given the likely increase in energy consumption to cool buildings during more frequent and extreme weather events such as heatwaves.

2.7 Health and well-being

Overview of strategic area: People spend about 90% of their time indoors, so the indoor environment has a significant effect on their health and well-being[29]. Many scientific studies show indoor environmental quality (IEQ) plays a crucial role in ensuring quality of life and general health and well-being[30]. The major determinants of IEQ are indoor air quality, and thermal, acoustic and lighting comfort. As well as improving IEQ, energy efficiency also helps reduce the use of fossil fuels, improving air quality[31]. Reducing energy consumption through building renovations also reduces energy poverty. Finally, energy efficiency

[26] The EU Adaptation Strategy is currently under revision. The revised strategy is expected to be published by late 2020 or early 2021.

[27] Commission Staff Working Document 'Adapting infrastructure to climate change', accompanying the document Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. An EU Strategy on adaptation to climate change, SWD/2013/0137 Final.

[28] Green Paper on the insurance of natural and man-made disasters, COM(2013) 213 final.

[29] World Health Organization, 2012. Burden of disease from Household Air Pollution for 2012.

[30] Al horr et al., 2016. Impact of indoor environmental quality on occupant well-being and comfort: A review of the literature, International Journal of Sustainable Built Environment, 2016, 5 1 11

[31] Environmental Protection Agency. Indoor Air Quality (IAQ), Health, Energy Efficiency and Climate Change (Available at: https://www.epa.gov/indoor-air-quality-iaq/health-energy-efficiency-and-climate-change)

renovations coupled with the elimination of accessibility barriers are also associated with increased well-being.

Key trends and drivers:

- The need to decarbonise the building sector should lead to increased renovation rates. This will have a positive effect on the health and well-being of occupants.
- Existing sustainable building certification systems such as DGNB[32], LEED[33], BREEAM[34], Home Performance Index[35] and WELL[36], support health and well-being at different levels, favouring the indoor environment, ecology, sociocultural aspects, active and healthy lifestyles and safety.

Description of EU framework:

- Article 2a of the EPBD requires Member States to incorporate in their long-term renovation strategy an evidence-based estimate of expected energy savings and wider benefits, such as those related to health, safety and air quality.
- The Commission Recommendation on building renovation[37] clearly mentions that measures to address energy performance can contribute to creating a healthy indoor quality environment. It spells out some of the wider benefits related to health and well-being such as lower illness and health costs, and greater labour productivity from better working and living conditions.
- The Directive on the accessibility requirements for products and services[38] aims to improve the functioning of the internal market for accessible products and services, including in the built environment.
- The EC framework for sustainable buildings – Level(s) – aims to unite the whole sector value chain around a common European language for better environmental performance of buildings, which takes into account wider aspects impacting health and well-being.

Impact on overall targets for the EU building sector: Increases in renovations motivated by improving health and well-being of EU citizens, including reducing energy poverty, can lead to an increase in overall building renovations, therefore supporting the decarbonisation of the sector.

3. Interactions between strategic areas

The seven strategic areas have interconnections and interactions: a policy measure in one area may have impacts on another. For example, policies to renovate buildings using a district approach can contribute to retrofitting the worst performing buildings (‘Engaging transformation and phasing out inefficient buildings’); have a positive effect on sustainable mobility through better urban planning (‘Clean and sustainable mobility’); and contribute to making buildings resilient to climate change (‘Built environment sustainability and adaptation to climate change’).

The table below gives an overview of the key interactions between strategic areas.

32 https://www.dgnb.de/en/
33 https://www.usgbc.org/leed
34 https://www.breeam.com/engage/research-and-development/consultation-engagement/active-design-and-breeam/
35 http://homeperformanceindex.ie/
36 https://www.wellcertified.com/
37 Commission Recommendation (EU) 2019/786 of 8 May 2019 on building renovation.
38 Directive (EU) 2019/882 of the European Parliament and of the Council of 17 April 2019 on the accessibility requirements for products and services.

	Clean & sustainable mobility	Digital technology	District approach	Engaging transformation	Financing renovation	Sustainability & adaptation to climate change	Health and well-being
Clean & sustainable mobility			Clean and sustainable mobility planning takes place at city or district level.	Clean and sustainable mobility measures, for example e-mobility chargers, can be a trigger for building renovations.			Clean and sustainable mobility measures contribute to reducing air pollution, including reduction of indoor air pollution.
Digital technology	Digital technologies are crucial to distribute the load impact of EV charging over time and to account for signals such as price or availability of locally produced energy.		Digital technologies are an enabling tool for energy communities.	Digital technologies enable industrialised renovation processes and enable the collection of buildings data that is the starting point to tailor renovation measures. They also provide consumers with information, for example on real-time energy consumption. Data security is important to gain trust.	Digital technologies make monitoring the performance of renovation measures possible, which is necessary to attract investment in building renovations.	Digital technologies/ Building Information Modelling enhance data availability (for example on materials) and thus facilitate circular approaches to building construction and renovation.	Digital technologies can help monitor health and well-being benefits and should help with recognising and reacting to occupants' needs in terms of comfort, health and IAQ.
District approach	District approaches can have a positive effect on sustainable mobility through better urban planning.			District approaches can contribute to engaging consumers and retrofitting the worst performing buildings in the district.	District approaches can help aggregate renovation opportunities and support economies of scale.	District approaches can contribute to making buildings resilient to climate change.	District approaches may improve social cohesion.

	Clean & sustainable mobility	Digital technology	District approach	Engaging transformation	Financing renovation	Sustainability & adaptation to climate change	Health and well-being
Engaging transformation	Building renovation can be the trigger to install electro-mobility infrastructure in buildings or to create spaces for softer mobility options, including bikes.	Building renovation at scale will increase the demand for and application of digital technologies to speed up processes and offer tailored solutions.	While transformation may be achieved faster when approached district by district, it may also complicate processes (for example, coordination with more stakeholders).		Building renovation can only be done at scale when there are available and accessible financing tools and business models.	Buildings renovations can be carried out in line with circular economy principles and can also be an occasion to make buildings resilient to climate impacts.	Buildings renovations improve comfort and well-being of building occupants.
Financing renovation		Financing schemes require calculation of, for example, performance and payback times. This information can be better gathered with digital technologies.	Financing renovations based on project aggregation is an enabling condition for retrofitting buildings using a district approach.	Financing renovations though appropriate tools and business models is the key enabling condition to make refurbishments happen on the ground.		Financing certain mitigation technologies may have adverse effects from an adaptation viewpoint.	
Sustainability & adaptation to climate change			Circular economy and adaptation technologies and processes can be applied by using a district approach.	Considering wider sustainability aspects may encourage renovation but also hamper its implementation due to additional	Circular economy and adaptation technologies and processes need the support of business models		Improving sustainability of the built environment and climate adaptation measures can contribute to the health and well-being of building occupants.

	Clean & sustainable mobility	Digital technology	District approach	Engaging transformation	Financing renovation	Sustainability & adaptation to climate change	Health and well-being
				regulatory complexity.	to become mainstream.		
Health and well-being			Health and well-being considerations can become a trigger for building renovations at district level as they would allow the exploitation of synergies with other areas, including clean and sustainable mobility.	Health and well-being considerations can become a driving force for building renovations.	When health and well-being benefits are fully considered and monetised, financing tools and business models for renovations become more valuable.	Health, well-being and comfort considerations can be a trigger to improve buildings' climate resilience.	

Table 7: Key interactions between strategic areas

ACTIVITY 1.3: KEY EU CHALLENGES

1. Introduction and methodology

The objective with Activity 1.3 was, for each strategic area, to identify the key challenges at the EU level to achieving net-zero GHG emissions by 2050 in a socially fair, cost-efficient way.

Below we present the key barriers and main factors for success in tables. These will be used as a basis for the policy assessment that is carried out in Tasks 2 and 3.

2. Key EU challenges

2.1 Key EU challenges in the 'Clean and sustainable mobility' strategic area

1) Creating sustainable city layouts

The dominance of the car as the prime mode of individual mobility is not just the result of technological developments in car manufacturing, but also urban and spatial planning. City planners have enabled increasing car use by planning cities and regions around it, by building the required road and parking infrastructure – at the expense of other options – and by establishing and enforcing a set of rules that gives cars priority over other transport modes. It is a key challenge to overcome this post-war paradigm in city planning and replace it with a model that puts sustainable options such as walking, cycling and electric vehicles at the centre. Getting citizens to accept new types of mobility is a key concern given most are used to individual ownership and use of cars. In dense agglomerations, some existing infrastructure, particularly roads and car parking, will need to make way for new infrastructure. New approaches have to be socially balanced. They have to take into account the needs of disadvantaged groups and require convenient alternative transport options. They should be debated and explained extensively.

2) Making buildings ready for e-mobility[39]

Analysis of potential decarbonisation pathways shows that electrifying transport is one of the most promising avenues for reducing GHG emissions from individual mobility. While electric vehicles remain a niche technology in most Member States, growth rates are pointing towards a considerable increase over the next decade.

Providing charging infrastructure is a key challenge to electrifying the transport sector. Buildings can support this by ensuring renovations are a trigger for installing charging points, not only for electric cars but also for electric bikes and scooters. It is also important to consider other barriers, like lack of easily available charging points for people in multi-apartment buildings. Similarly, the lack of adequate infrastructure such as garages for bikes, including cargo bikes, is an additional barrier to developing softer mobility options.

3) Increasing joint investment in buildings and mobility

An overarching challenge in the interplay between mobility and buildings is finance. Rising rents and property prices are a widespread social concern in European cities. Adding further costs to build new or refurbish dwellings to facilitate and promote sustainable mobility options can therefore become a social concern. Smart financing and support instruments

[39] Electric mobility (e-mobility) refers to different types of electrified vehicles, including electric cars, electric bikes, electric scooters and electric motorcycles.

are key to developing infrastructure for sustainable mobility while protecting social cohesion.[40]

The following tables summarise key barriers and success factors for each of the EU challenges above.

[40] See for example, Tomassini et al. (2016). EU financial support to sustainable urban mobility and to the use of alternative fuels in EU urban areas.

EU CHALLENGE 1: Creating sustainable city layouts						
	LEVEL OF IMPLEMEN-TATION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
BARRIERS	There is little coordination between the different governance levels on mobility infrastructure development.	Developers focus on value of property above all other considerations.	Local policymakers do not have legal tools to enforce rules on sustainable city layouts if developers do not agree. Local policymakers often lack skills to plan adequate sustainable transport infrastructure.		Citizens may initially oppose a layout prioritising walking, biking and shared transport options over private cars.	
SUCCESS FACTORS	Integrated planning processes with participation of all relevant governance levels.	Incentives for sustainable mobility infrastructure and disincentives for private car ownership.	Dedicated legal provisions encouraging sustainable city layout.		Pilot projects, even when limited in time, can help to overcome opposition.	Highlighting co-benefit.

Table 8: Summary of key barriers and success factors for 'Creating sustainable city layouts'

EU CHALLENGE 2: Readying buildings for e-mobility						
	LEVEL OF IMPLEMENTATION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
BARRIERS		Low demand for charging infrastructure.	Uncertainty about mechanism to bill costs of charging.	Uncertainty about future standards for charging devices.	Rising housing costs are a growing social concern in many Member States.	
SUCCESS FACTORS		Economic incentives for electric vehicles create demand for charging infrastructure in buildings. Innovative financing schemes or service solutions.	Giving cities a clear target to make e-mobility the norm, supported by extensive and complementary support measures.		Increasing demand from first adopters of electric vehicles.	

Table 9: Summary of key barriers and success factors for the EU challenge "Making buildings ready for e-mobility

EU CHALLENGE 3: Increasing joint investment in buildings and mobility						
	LEVEL OF IMPLEMENTA-TION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
BARRIERS	Infrastructure decisions for neighbourhood-based mobility are made at local level.	Municipalities often face budget restrictions.	Lack of finance expertise in municipalities to explore innovative finance models.		Increasing housing costs. Municipalities may face resistance when demanding that developers install sustainable mobility infrastructure.	
SUCCESS FACTORS	Partnerships between government levels to leverage EU or national resources for local investment.	Availability of smart financing support tailored to the needs of municipalities.			Support and demand from citizens for clean mobility solutions.	

Table 10: Summary of key barriers and success factors for 'Increasing joint investment in buildings and mobility'

2.2 Key EU challenges in the 'Digital technology' strategic area

1) Unleashing the flexibility potential of energy uses via digitalized energy-consuming appliances and services

Integrating distributed energy sources at low voltage level poses a challenge as grids were not initially designed to host bidirectional energy flows. In addition, the lack of a clear framework and high equipment costs might hamper self-consumption of locally produced renewable energy. While flexibility services exist for larger energy consumers (such in the industry or services sectors), flexibility at the level of residential buildings is less organised. Digitisation is a key enabler of energy uses/consumption patterns that adapt to variable production sources to balance consumption with production. The key challenge is to harvest small-scale flexibility and organise its use in ways that 1) foster local consumption of decentralised and variable energy sources, including at the scale of one/several buildings (energy communities), and 2) support the global energy system with flexible energy consumption patterns. This will prevent decarbonisation of the energy system significantly increasing energy system costs.

2) Mainstreaming optimal energy uses via digitalized energy-consuming appliances and services

Optimising energy use through digitalisation helps reap the full benefits of deep renovations; self-regulating devices limit unnecessary energy use and help address technical failures that could lead to additional energy consumption. However, mainstreaming digitalisation techniques to enable smart buildings is hampered by split incentives (building owners who do not occupy their buildings have no direct incentive to increase energy performance by installing self-regulating devices) and the cost of digitalisation for building technical systems.

3) Digitalize the buildings renovation supply chain

The whole building supply chain can benefit from digitalisation, for example by using Building Information Modelling. This eases interactions between contractors, spots design problems and optimises management of the building during its lifecycle, ultimately helping to reduce its energy consumption. However, there are many barriers to making these benefits a reality, such as the large variety of small-scale contractors, the lack of standards and skilled workers to digitise the sector, and the costs of software acquisition and training.

4) Digitalize data collection of information about the building stock across Europe

There is an increasing amount of data available on building energy use and building occupants' energy consumption patterns. Collecting these data and making them available in a transparent way would be useful both for policymaking and to support the creation of innovative energy service and business models. To this end, the key challenge is to create a framework that systematises data collection by allowing the integration of data from different sources (for example, smart meters and energy performance certificate repositories), and the automation of the process with minimal or no manual intervention. Any digitalisation of data collection should be compliant with data protection regulations, with data kept securely.[41]

[41] Challenge expressed by the Commission in its H2020 call 'European building stock data 4.0'. Available at: https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/lc-sc3-b4e-7-2020, last accessed 26 February 2020.

The following tables summarise key barriers and success factors for each of the EU challenges above.

EU CHALLENGE 1: Unleashing the flexibility potential of energy uses via digitalized energy-consuming appliances and services						
	LEVEL OF IMPLEMEN-TATION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
BARRIERS	Low digitisation of Europe compared to other economies.[42]	Cost of installing regulating devices that adapt consumption to an external signal. Split-incentive dilemma. Purchase cost of smart appliances.	Lack of clearly defined roles on who should operate flexibility. Cyber security, protection of consumer data. Lack of a clear legislative framework on energy communities/self-consumption.	Buildings are the least digitised sector in Europe. Diversity of interfaces and communication protocols. No time-of-use signals ready to be used yet.	Resistance to change. Fear of loss of comfort and control. Data privacy. Lack of skilled workers. Weak understanding from occupants.	Specific resources needed (rare materials) for IT devices. Connected appliances have higher energy consumption.
SUCCESS FACTORS		Incentivising the installation of regulation devices and the purchase of smart appliances.	Clear market framework with defined roles. Definition of a clear framework for energy communities/self-consumption.	Inclusion of EV charging stations. Standardisation of communication protocols.	Raising awareness of building users. EU programmes incorporating these skills into education/training.	

Table 11: Summary of key barriers and success factors for the EU challenge `Unleashing the flexibility potential of energy uses via digitalized energy-consuming appliances and services´

[42] https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/digital-europe-realizing-the-continents-potential

EU CHALLENGE 2: Mainstreaming optimal energy uses via digitalized energy-consuming appliances and services						
	LEVEL OF IMPLEMENTA-TION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
BARRIERS		Cost of installing regulating devices. Low replacement cycles. Split-incentive dilemma.	Cyber security, protection of consumer data.	Buildings are the least digitised sector in Europe. Invisibility of energy consumption leads to significant energy volumes being consumed unnecessarily.	Weak understanding of the systems by the occupants. Lack of skilled workers.	Specific resources needed (rare materials) for IT devices. Connected appliances have higher energy consumption.
SUCCESS FACTORS **SUCCESS FACTORS**	Replacement of old systems encouraged. EU framework (EPDB) for the deployment of BAMS. The Digital Europe Programme intends to ensure wide use of digital technologies across the	Adequate incentives to foster the development of smart regulated systems.			Increasing awareness. EU programmes incorporating these skills into education/training .	

EU CHALLENGE 2: Mainstreaming optimal energy uses via digitalized energy-consuming appliances and services						
	LEVEL OF IMPLEMENTA-TION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
	economy and society.[43]					

Table 12: Summary of key barriers and success factors for 'Mainstreaming optimal energy uses via digitalized energy-consuming appliances and services'

EU CHALLENGE 3: Digitalize the buildings renovation supply chain						
	LEVEL OF IMPLEMENTA-TION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
BARRIERS	The construction value chain is very fragmented and has different needs, depending on the size of companies.	Cost of software acquisition and training employees/workers, especially for smaller structures.	Lack of national standards. Cyber security, protection of consumer data.	Buildings are the least digitised sector in Europe.	Lack of skilled workers. Coordination between various actors/ contractors. Variety of small actors. Lack of awareness.	

[43] https://ec.europa.eu/digital-single-market/en/news/digital-europe-programme-proposed-eu92-billion-funding-2021-2027

EU CHALLENGE 3: Digitalize the buildings renovation supply chain						
	LEVEL OF IMPLEMENTA-TION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
SUCCESS FACTORS	The Digital Europe Programme intends to ensure wide use of digital technologies across the economy and society.[44]	Financial support for digitalisation.	Harmonisation of standards.		EU programmes incorporating these skills into education/training. Leadership from the master of works. Increasing awareness.	

Table 13: Summary of key barriers and success factors for 'Digitalize the buildings renovation supply chain'

EU CHALLENGE 4: Digitalize data collection of information about the building stock across Europe						
	LEVEL OF IMPLEMENTA-TION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
BARRIERS		Cost of collecting data.	Data privacy. Cyber security.	Lack of quality data on the building stock.	Data privacy.	

[44] https://ec.europa.eu/digital-single-market/en/news/digital-europe-programme-proposed-eu92-billion-funding-2021-2027

				Lack of standardisation. Integration of data from multiple sources. Need for manual input.		
SUCCESS FACTORS	Deployment of energy performance certificates. Deployment of building renovations passports and digital logbooks. Local authorities contributing to data collection.	Showcasing innovative energy services, new business models and financing schemes based on digitised collection of buildings data.		Standardisation of data.	Policies aiming to detect energy poverty situations that require data collection Enhanced consumer information.	

Table 14: Summary of key barriers and success factors for 'Digitalize data collection of information about the building stock across Europe'

2.3 Key EU challenges in the 'District approaches' strategic area

1) Develop integrated approaches maximizing the synergies between energy efficiency and renewable energy at the district level

Energy efficiency and renewables measures are not often planned together. A key challenge is to start developing integrated approaches, particularly at the district level, to find an optimal combination between the two and ensure the potential of both is maximised. Optimal renewable energy solutions are more likely to be found when solar energy, ground heat, storage etc. are designed on a district level[45]. Developing solutions at the district level is the only way to ensure building-specific measures to improve energy efficiency affect the entire residential district and its energy production[46]. Furthermore, if strategic decisions about supply and demand of available (heat) resources are made at a higher level of governance (regional and local), this would also guide decisions on viable options at neighbourhood or district level[47].

2) Streamline and aggregate renovation solutions and processes at the neighborhood level

Buildings in residential districts typically have common characteristics, requiring similar renovation solutions. However, very often renovation opportunities are not aggregated at the district level. A key challenge is to identify and capture opportunities for standardization and aggregation at the district level. This will help speed up renovation, provide economies of scale and foster quality by giving opportunities to draw learnings as renovations are replicated from one site to others. Using prefabricated renovation solutions, and developing lean and integrated renovation processes, practices and services, can support this.

3) Develop comprehensive (sub)urban strategies combining energy and carbon efficiency of the building stock with sustainable solutions for growth and improvement of citizens' wellbeing

Growing populations and evolving living and mobility patterns may lead to an unsustainable urban exodus. A key challenge is to embed building energy renovation into global territory planning strategies. Planning renovation and infill strategies at the district level maximises benefits and increases positive synergies. To cover the growing need for buildings while preventing urban sprawl and limiting the environmental impact of new construction, infill projects in existing urban and sub-urban districts and reusing existing urban infrastructure should be prioritised[48]. This is also a potential way to finance energy refurbishment of buildings. District planning is also an opportunity to rethink mobility needs and solutions and put in place sustainable solutions.

The following tables summarise key barriers and success factors for each of the EU challenges above.

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[45] T. Häkkinen (2018), District-scale energy refurbishment helps to achieve low-carbon targets, available at: https://vttblog.com/2018/09/14/district-scale-energy-refurbishment-helps-to-achieve-low-carbon-targets/, (last accessed 26 February 2020).

[46] S. Pahio (2015), It is more sensible to renovate entire residential districts than individual buildings, available at: https://vttblog.com/2015/11/19/it-is-more-sensible-to-renovate-entire-residential-districts-than-individual-buildings/ (last accessed 26 February 2020).

[47] H. Vandevyvere, G. Reynders, R. Baeten, I. De Jaeger, Y. Ma (2019), The trade-off between urban building stock retrofit, local renewable energy production and the roll-out of 4G district heating networks, available at: https://www.energyville.be/sites/energyville/files/position_paper_per_blad.pdf (last accessed 27 February 2020).

[48] T. Häkkinen (2018), District-scale energy refurbishment helps to achieve low-carbon targets, available at: https://vttblog.com/2018/09/14/district-scale-energy-refurbishment-helps-to-achieve-low-carbon-targets/, (last accessed 26 February 2020).

EU CHALLENGE 1: Develop integrated approaches maximizing the synergies between energy efficiency and renewable energy at the district level						
	LEVEL OF IMPLEMENTA-TION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLO-GICAL**	**SOCIAL**	**ECOLOGICAL**
BARRIERS	National objectives and policies do not always facilitate an integrated approach to energy efficiency and renewable energy.	Large-scale innovative systems are not cost-effective from the beginning.	Optimal technologies identified can be available on the market but still difficult to implement because the legal framework is not supportive.		Lack of sufficiently skilled professionals at the local level.	
SUCCESS FACTORS	Mapping of zones at the local level with potential for specific technologies (for example, heat capacity mapping). Creating renovation platforms at local level	Implementation of technological solutions at large scale offers cost reduction potential.	Incentive measures and policies. Financial measures supporting new technologies to make them attractive.		Matching training and education with the skills needed in the market. Skilled and qualified professionals.	Large-scale initiatives leading to development of local renewable energy potential, otherwise unexploitable at smaller scale.

Table 15: Summary of key barriers and success factors for ‘Develop integrated approaches maximizing the synergies between energy efficiency and renewable energy at the district level’

EU CHALLENGE 2: Streamline and aggregate renovation solutions and processes at the neighborhood level						
	LEVEL OF IMPLEMENTATION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
BARRIERS	Lack of national strategy to coordinate different independent initiatives.		Administrative burden to realise solutions at national level (for example, tax law and PV support regulation).	Project aggregation is complex and time-consuming.	Disagreement of some owners to start district-scale projects. Lack of skilled professionals at local level.	
SUCCESS FACTORS	Tools to identify local potentials or district with standardisation potential. Tools to secure an identified renovation volume with great potential for district approach. Creating renovation platforms at local level.	Finance support for renovation. Tools to support the creation of economy of scale (such as group procurement, joint ventures in procuring design, construction and other services).	Supporting the creation of renovation facilitators.	Prefabricated renovation solutions. Developing standardised renovation processes, practices and services.	Match training and education with the skills needed in the market. Including citizens in project conception. Availability of skilled professionals.	

Table 16: Summary of key barriers and success factors for 'Streamline and aggregate renovation solutions and processes at the neighborhood level'

EU CHALLENGE 3: Develop comprehensive (sub)urban strategies combining energy and carbon efficiency of the building stock with sustainable solutions for growth and improvement of citizens' wellbeing						
	LEVEL OF IMPLEMENTA-TION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE /LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
BARRIERS	Lack of integrated approaches to urban planning.		Public administration departments often work in silos.		Lack of sufficient skilled professionals in public authorities.	
SUCCESS FACTORS		Combining building renovations at the district level with investment in sustainable mobility.	Institutional and legal obstacles related to town planning and building permission practices.	Tools to identify local potential for infill projects.	Including citizens in project conception.	Integrated strategy leads to optimal renovation of the district, including integrating green areas.

Table 17: Summary of key barriers and success factors for 'Develop comprehensive (sub)urban strategies combining energy and carbon efficiency of the building stock with sustainable solutions for growth and improvement of citizens' wellbeing'

2.4 Key EU challenges in the 'Engaging transformation and phasing out inefficient buildings' strategic area

1) Create an enabling framework for deep renovations that are not cost-effective

Deep building retrofits are not always cost-effective under current calculation methods. A contributing factor is that non-energy benefits of renovations are difficult to monetise and account for. The challenge is to create an enabling framework to make those non-economical renovations, or those with a very long payback period, happen, and to advance approaches that take into account wider benefits.

2) Trigger acceptance and behavioral change of building owners and occupants about deep energy renovations

Consumer demand for deep energy renovations is key to kick-starting the renovation market. When citizens actively demand and carry out deep renovations in their homes, the renovation rate will start increasing. To make this happen, deep renovations need to be made desirable and accessible to citizens, for example, by becoming affordable and easy to carry out. Thus, the challenge is to understand individual consumer needs and match those to the renovation solutions in a market currently driven by offers that do not necessarily reflect long-term targets or individual circumstances. Solutions could include providing tailored advice and support for renovations, as well as clear explanations (and quantifications) of the non-energy related benefits of renovations.

Another issue is ensuring building occupants can operate their homes efficiently. For example, they should be aware of the energy they consume, and know how to use heating equipment and ventilation systems efficiently. The challenge is to find solutions that, for example, make alternatives more attractive, change people's default settings and behaviour, and increase automation.

3) Accelerate the market penetration of innovative solutions for deep renovations

To increase the rate of deep energy renovations, innovative solutions must emerge from the niche market and become mainstream. The construction sector is one of the least innovative of all sectors. In recent years, the construction sector – from planning to operation – has been profitable with its existing approaches, so investing in innovation has not been a priority.

Policies and measures are needed to encourage new business models. These could include mainstreaming energy performance contracting for different user groups, and promoting innovative solutions to industrialise renovations, for example by using more prefabricated modules or plug-and-play solutions for suitable building types. In addition, better training is needed for the construction sector's workforce, so they are able to deliver good quality renovations using state-of-the-art technologies.

4) Achieve deep energy renovations in a heterogenous building stock with mixed ownership

Building typologies vary considerably across the EU and so does the ownership tenure of buildings. It is very difficult to address this diversity with one-size-fits-all measures. It is difficult to set up specific incentives and initiatives to target specific building segments and population groups in a consistent way, making sure that target groups and long-term targets are addressed properly and progress is tracked in fragmented markets. To overcome this challenge, measures to address heterogenous interests (for example, the split-incentive dilemma) in combination with a consistent monitoring approach may be helpful.

The following tables summarise key barriers and success factors for each of the EU challenges above.

EU CHALLENGE 1: Create an enabling framework for deep renovations that are not cost-effective						
	LEVEL OF IMPLEMENTA-TION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
BARRIERS	Misalignment between different governance levels on renovation strategies.	Deep renovations have a long pay-back time. Low energy prices. High up-front costs for deep renovations. Difficult to aggregate small projects. Split-incentive dilemma.	Definition of cost-effectiveness/ application of economic viability principle.	Lack of digitalisation in the construction sector. Aggregation and standardisation of solutions not mainstreamed yet.	Lack of qualified work force. Lack of awareness about health and well-being benefits of renovated buildings.	
SUCCESS FACTORS	EU policy-making as stimulus for national action.	Reforming definition of cost-effectiveness, to include wider benefits. Stepping up funds for deep renovation.	Policy instruments designed in view of long-term objectives. Standardised energy performance contracts.	Prefabricated renovation solutions.		

Table 18: Summary of key barriers and success factors for 'Create an enabling framework for deep renovations that are not cost-effective'

EU CHALLENGE 2: Trigger acceptance and behavioral change of building owners and occupants about deep energy renovations						
	LEVEL OF IMPLEMENTATION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
BARRIERS	Incentives set at supranational or national level need to target citizens in their specific surroundings.	Low energy prices. Market failure, split-incentive dilemma.		Lack of understanding of renovation technologies and processes.	Lack of understanding of non-energy benefits of renovations.	
SUCCESS FACTORS	Support from local authorities for renovations.	Targeted financial incentives. Tailored advice for renovations.	One-stop-shop solutions.	Digital solutions give feedback to consumers. 'Ownership' of technological solutions (prosuming).	Participation in renovation decision-making	

Table 19: Summary of key barriers and success factors for the EU challenge "Trigger acceptance and behavioral change of building owners and occupants about deep energy renovations"

EU CHALLENGE 3: Accelerate the market penetration of innovative solutions for deep renovations						
	LEVEL OF IMPLEMENTA-TION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
BARRIERS		Lack of appropriate business models.	Long permit procedure.	Lack of understand-ding of renovation technologies and processes. Adaptable modules for new builds and renovation. Lack of individualisation of possible solutions.	Difficult to address mixed-ownership structures of buildings.	
SUCCESS FACTORS		Performance-based requirements to trickle down the renovation supply chain.	Standardised approaches to facilitate permit procedures.	Support for innovative technologies, such as prefabricated facades, plug-and-play solutions and energy modules. Aggregation of deep renovation projects at district level.		Performance criteria beyond energy requirements (for example, circularity, materials, climate resilience).

Table 20: Summary of key barriers and success factors for 'Accelerate the market penetration of innovative solutions for deep renovations'

EU CHALLENGE 4: Achieve deep energy renovations in a heterogenous building stock with mixed ownership						
	LEVEL OF IMPLEMENTATION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
BARRIERS	Misalignment between different governance levels on renovation strategies.	Lack of targeted financial support. Long payback periods for renovation. Split-incentive dilemma.	Decision-making process for building renovations in multi-family buildings.	Lack of good data about the building stock.		
SUCCESS FACTORS	Local support schemes accompanied by planning processes that take into account social cohesion and district approaches.	Targeted financial incentives for specific building types and ownership tenure. Tailored advice to buildings' owners	Streamlining procedures, decisions not requiring unanimity or very high majorities in multi-family buildings.		Co-benefits including social cohesion.	

Table 21: Summary of key barriers and success factors for 'Achieve deep energy renovations in an heterogenous building stock with mixed ownership'

2.5 Key EU challenges in the 'Financing renovation' strategic area

1) Unlocking financing for renovations for the end-users

To increase renovation rates, there is a clear need to create mechanisms and support programmes with the financing capacity to stimulate investments, including to target buildings occupied by the most vulnerable consumers.

To achieve lower-cost financing and better access for tenants and occupants, the creditworthiness and security of repayments for energy efficiency retrofits must be improved. Building occupants are the most engaged stakeholders. However they are also the least likely to engage in building renovation unless they own their home.

Many end-users also lack available funds to carry out renovations. Banks and energy suppliers involved in supplying energy-efficient retrofit solutions to their individual and commercial customers could offer more profitable products to their customers.

Investment from the public sector is also necessary to overcome key challenges. Member States should implement and design effective mechanisms that allow all users to carry out renovations at a reasonable cost. These should take the difficulties they may face into consideration (for example, lack of funds and high upfront costs).

2) Financing building renovations in the presence of market failures

Adequate financial instruments to overcome market failures are of central importance to achieve and sustain higher deep renovation rates. Market failures are understood as a range of problems that tend to delay the transformation of building stock and the tapping of cost-effective energy savings potential. They may include lack of understanding of energy use in buildings and potential savings resulting from renovations; lack of attractive financial products; high upfront costs of renovation and their long payback period; low energy prices negatively affecting payback of energy savings measures; limited information and data availability about the building stock; limited uptake of efficient and smart technologies; and split incentives.

Adequate financial instruments to overcome market failures, a sufficient workforce with the right skills, and affordability for all citizens are very important if the EU is to achieve and sustain higher renovation rates.

3) Mobilising sustainable investment and de-risking energy efficiency investment

Lack of evidence on the performance of energy efficiency investments in buildings makes financial risk harder to assess and mobilisation of both public and private investments more difficult. On one hand, suitable platforms for dialogue and exchange of good practice, which promote the provision of reliable, comparable and verifiable information, are needed to de-risk energy efficiency investments and engage stakeholders. On the other hand, there is a lack of standard financial approaches for building renovations, such as agreed protocols and benchmarking rules for private capital investment, and 'ready to use' financial products that would facilitate de-risking of investments.

Risks related to energy efficiency investments can fall under five categories: economic and financial, behavioural and operational, measurement and verification, contextual and technology, and regulatory. The factors that determine how risks/barriers can be categorised and solved range from market-specific (for example, lack of appropriate financing vehicles or debt instruments, regulatory risks, volatile energy prices) and investor-specific (for example, risk aversion, behavioural bias, perceived lack of collateral), to project-specific barriers (for example, high initial costs, long payback periods, uncertainty of technology).

The following tables summarise key barriers and success factors for each of the EU challenges above.

EU CHALLENGE 1: Unlocking financing for renovations for the end-users						
	LEVEL OF IMPLEMENTA-TION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
BARRIERS	Difficulties in channelling EU and national funds to local renovation projects.	True costs of CO_2 emissions are not reflected in market prices. Lack of available funds for energy efficiency renovations. Split-incentive dilemma. Arrears on utility bills. High upfront costs of renovation and long payback.	Lack of a harmonised definition and measure of energy poverty across the EU.	Inefficient energy performance of buildings (thermal insulation, heating systems and equipment) lead to an increase in energy bills.	Higher property value, which can lead to higher rents. Households that struggle to pay the bills. Lack of understanding of energy use and potential savings. Limited information on the effectiveness of currently available financial support mechanisms.	Lower energy prices (natural gas vs electricity) and lower capital costs (gas boilers tend to be less expensive in most countries than heat pumps) mean higher performance equipment may barely break even on a lifecycle basis.
SUCCESS FACTORS **SUCCESS FACTORS**	Ensuring that local authorities are able to apply for EU and national funds and can	Energy tariffs. Boosting effective use of financial tools, such as tax incentives, and	Integrated national action plans. Better monitoring and sharing of best practices.	Determining the worst-performing segment by setting a specific threshold.	Education and awareness tools, training and capacity-building.	Increasing awareness of alternative and more efficient technologies.

EU CHALLENGE 1: Unlocking financing for renovations for the end-users						
	LEVEL OF IMPLEMENTA-TION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
	channel them to the best local projects.	linking them with R&D activities to reduce the cost of more efficient equipment. Incentives to owners or tenants through subsidies and financial mechanisms.	Improving policy regulations and market signals related to energy efficiency and CO_2 emissions in the building sector.		Investing in reskilling and upskilling of the workforce. Reliable, comparable and verifiable information. Cross-sectoral measures that ensure nobody is left behind. Adoption of social policy measures.	

Table 22: Summary of key barriers and success factors for 'Unlocking financing for renovations for the end-users'

EU CHALLENGE 2: Financing building renovations in the presence of market failures						
	LEVEL OF IMPLEMEN-TATION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
BARRIERS		Lack of consistent and comparative information. Lack of attractive financing products. High upfront costs of renovation and long payback. Stranded assets. Benefits are in the form of savings rather than revenues. Split-incentive dilemma.	Limited consideration of benefits due to energy renovation in lending decision criteria.	Limited uptake of available funds to finance efficient and smart technologies.	Limited information on the effectiveness of currently available financial support mechanisms. Lack of understanding of potential energy savings and other benefits.	Lower energy prices (natural gas vs electricity) and lower capital costs (gas boilers tend to be less expensive in most countries than heat pumps) mean higher performance heat pumps may barely break even on a lifecycle basis. Therefore, buildings remain carbon-intense energy vectors.
SUCCESS FACTORS		Better targeted subsidies. Mobilisation of public funding to leverage additional private	Policies and measures to stimulate cost-effective deep renovations of buildings.	Achieving high energy efficiency through optimal operation of buildings and facilitating maintenance of	Reliable, comparable and verifiable information. Fuel poverty alleviation.	

EU CHALLENGE 2: Financing building renovations in the presence of market failures						
	LEVEL OF IMPLEMEN-TATION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
SUCCESS FACTORS		sector investment and address market failures. Innovative schemes such as energy services companies (ESCOs) or on-bill and on-tax mechanisms. Risk-sharing instruments such as loans, guarantees and technical assistance	Long-term policy signals. Public authorities, including the EU institutions, leading by example and ensuring that their procurement is green, providing evidence of advantages. Improving policy regulations and market signals related to energy efficiency and CO_2 emissions in the building sector.	technical building systems. Digital transformation. Improving the availability of information to the public and other actors when making purchasing decisions, such as labelling programmes.		

Table 23: Summary of key barriers and success factors for 'Financing building renovations in the presence of market failures'

EU CHALLENGE 3: Mobilising sustainable investment and de-risking energy efficiency investment						
	LEVEL OF IMPLEMEN-TATION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLO-GICAL**	**SOCIAL**	**ECOLOGICAL**
BARRIERS		True costs of CO_2 emissions are not reflected in market prices. Lack of access to reliable, comparable and verifiable information. High upfront costs of renovation and long payback. Retrofits do not produce direct income streams; rather they create avoided costs. Lack of attractive financing products. Small-size investments which increase implementation costs and reduce bankability.	Lack of large-scale structured collaboration between stakeholders across the value chain. Lack of standard financial approaches for building renovation.	Stranded assets.	Financial risk perception. Limited access to equal finance for end-users.	Lack of definition of 'green assets' (EU taxonomy)
SUCCESS FACTORS	Transversal measures that ensure nobody is left behind.	Using economic tools, such as a carbon tax, to improve pricing dynamics for clean energy solutions. Higher property values, rental incomes, lower tenant turnover and the ability to attract grants or subsidies.	Setting of ambitious and clear milestones within long-term renovation strategies is key to reducing investor risks and uncertainties, and engaging	Building renovation passports are an example of a measure Member States can use to support targeted cost-effective renovation and	Reliable, comparable and verifiable information.	

EU CHALLENGE 3: Mobilising sustainable investment and de-risking energy efficiency investment						
	LEVEL OF IMPLEMEN-TATION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLO-GICAL**	**SOCIAL**	**ECOLOGICAL**
SUCCESS FACTORS		Key financial mechanisms to be promoted include tax-related measures (tax incentives and credits on income, property and energy tax), on-bill financing, mortgages for energy efficiency, green bonds, grants and market-based instruments. Innovative financing schemes under InvestEU, the European Bank for Reconstruction and Development, the European Investment Bank and structural funds such as the European Structural and Investment Fund and European Social Fund.	stakeholders and business. Screening and benchmarking green budgeting practices, enabling buyers to make more sustainable decisions. Public authorities leading by example and ensuring their procurement is green. Changing risk perception of financers and investors. Clear long-term signals for private sector investment.	staged deep renovation. Smart infrastructure and digital transformation.		

Table 24: Summary of key barriers and success factors for 'Mobilising sustainable investment and de-risking energy efficiency investment'

2.6 Key EU challenges in the 'Built environment sustainability and adaptation to climate change' strategic area

1) Designing sustainable buildings taking into account the lifecycle of materials

Today's commercial and residential buildings are rarely designed for extended use, for accommodating different kinds of building uses through modularity, or for reuse and recycling during deconstruction. Therefore, buildings end up being deconstructed before their functional end-of-life, leading to large quantities of construction and demolition waste. This is rarely used for new buildings and so does not reduce the need for new, virgin construction materials.

Producing construction materials is associated with significant GHG emissions. More circular building design can help lower emissions by slowing down and reducing the need for new construction materials. Key challenges are to integrate circularity into existing design education and practices as well as into building owners' and investors' decision-making. This requires coordination, dialogue and efforts across buildings' value chains.

2) Fostering reuse and recycling of building materials and components

The low prices of virgin construction materials and low value of end-of-life materials disincentivise deconstruction practices oriented towards reuse and recycling. This reduces the availability and use of secondary construction materials. Given this low demand, a key challenges is to step up research and development in the sector to ensure better quality and higher performing secondary materials.

Another key challenge is to increase acceptance of and demand for secondary construction materials. Building designers, construction material manufacturers, architects and building owners still have many reservations about using secondary materials. There may also be uncertainty about their performance, which can lead to problems with building warranties.

3) Apply technical adaptation measures that have limited negative side-effects

Technical adaptation measures can be divided between (1) measures connected to buildings' position and orientation and (2) measures directly applied in buildings, such as air-conditioning, shading systems and rainwater harvesting. A key challenge is to ensure that both types of measures are taken into account from the very early stages of the building design and construction process.

A second key challenge is that many technical adaption measures have negative environmental side effects, such as increasing energy demand (especially true for air-conditioning). To avoid major trade-offs it is important to promote measures with low negative side effects, for example energy-efficient measures such as passive cooling systems (shading systems, passive cooling walls). Climate-resilient approaches promoted through building codes or (private or public) financial instruments should aim to reduce the negative side effects. It should also be noted that technologies installed in buildings to reduce emissions can be vulnerable to climate impacts.

4) Increase awareness and implementation of nature-based solutions

Nature-based solutions in, on and around buildings increase climate resilience and offer additional co-benefits such as improving air quality, protecting biodiversity, reducing urban heat island effects, contributing to stormwater management and extending the life of roof membranes. A key challenge is the lack of awareness of nature-based solutions and their multifunctional potential and ability to deliver diverse benefits. This is worsened by a lack of technical expertise and by the absence of a specific legal framework, including standards, requirements and financial support/incentives (particularly targeting the private sector). These factors limit the uptake of nature-based solutions and the willingness of decision-makers and other stakeholders to choose green over the more established ‘grey infrastructure’ status quo solutions.

The following tables summarise key barriers and success factors for each of the EU challenges above.

EU CHALLENGE 1: Designing sustainable buildings taking into account the lifecycle of materials						
	LEVEL OF IMPLEMENTA-TION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
BARRIERS	EU-wide, national and regional coordination is mostly insufficient.	Cheap virgin construction materials. Lower value of end-of-life materials. High(er) investment costs and insufficient market mechanisms to aid circular design, reuse and recycling.	Lack of legal requirements to foster CE principles. Warranty issues around using reused materials.	Limited access to sufficient quantity and quality of secondary materials. Lack of effective separate collection and recovery infrastructure.	Insufficient coordination among value chain actors. Low acceptance of secondary materials.	-
SUCCESS FACTORS	Regional or national coordination supporting pilot cases.	Raising prices for virgin materials. Providing financial support.	Providing guidelines on the use of Green Public Procurement for circular buildings.	Availability of alternative and applicable new/pilot technologies.	Circular buildings fostering employment and design for health.	Avoiding sites for construction mineral extraction.

Table 25: Summary of key barriers and success factors for 'Designing sustainable buildings taking into account the lifecycle of materials'

EU CHALLENGE 2: Foster new technologies and business models enabling reuse and recycling of building materials and components						
	LEVEL OF IMPLEMENTA-TION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE /LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGI-CAL**
BARRIERS	Intra-sectoral and value chain coordination insufficient.	Cheap virgin construction materials. Low value of end-of-life materials. High investment costs and insufficient market mechanisms to aid reuse and recycling.	Lack of legal requirements to foster reuse/recycling. Warranty issues around using reused materials.	Immature technologies for sorting and recycling (parts of) construction and demolition waste. Limited access to sufficient quantity and quality of secondary materials. Lack of effective separate collection and recovery infrastructure. Lack of data to label and trace material.	Low acceptance of secondary materials.	
SUCCESS FACTORS	Intra-sectoral and value chain coordination supporting marketable pilot cases.	Raising prices for virgin materials. Emerging business opportunities, for example due to Green Public Procurement.	Providing guidelines on the use of Green Public Procurement for circular buildings.	Availability of alternative and applicable new/pilot technologies.	Reuse and recycling more job intense than virgin extraction.	Avoiding sites for constructio n mineral extraction.

Table 26: Summary of key barriers and success factors for the EU challenge `Foster new technologies and business models enabling reuse and recycling of building materials and components'

EU CHALLENGE 3: Apply technical adaptation measures that have limited negative side effects						
	LEVEL OF IMPLEMENTA-TION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE / LEGAL**	**TECHNOLOGI-CAL**	**SOCIAL**	**ECOLOGICAL**
BARRIERS	Insufficient cooperation between the different governance levels, especially down to local level. Standardisation organisations not actively involved (especially with private organisations).	Large number of buildings are in private ownership – private owners need incentives to make climate resilience-related investments; partial measures which would be cheaper to implement during the building process are shifted to use phase. Additional costs, especially for energy-efficient solutions (for example cooling).	In some Member States requirements for reuse of water are not regulated. Therefore, measures cannot be implemented. Climate impacts not integrated into building codes.	For water re-use, high water quality is necessary.	Awareness is still low due to local specific risk situations (elevations, etc.). Acceptance is low for a number of measures (negative impacts for the buildings are expected).	Additional cooling measures can link to increased energy use.
SUCCESS FACTORS	Increasing coordination across governance levels and sectors, including private actors.	Cities developing clear requirements for buildings in certain areas during official approval processes (for example, passive cooling, flood protection); Guidelines could support cities.	Establishing legal requirements for water reuse. Guidelines on legal requirements for water reuse.	Identifying clear categories showing which types of water can be used for which purposes.	Local-specific risk mapping being available to inform building owners about risk of extreme events.	Legal requirement for energy-efficient solutions (for example, passive cooling).

EU CHALLENGE 3: Apply technical adaptation measures that have limited negative side effects						
	LEVEL OF IMPLEMENTA-TION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE / LEGAL**	**TECHNOLOGI-CAL**	**SOCIAL**	**ECOLOGICAL**
SUCCESS FACTORS	Standardisation organisations are key players and are actively involved in decision-making processes.	Further financing possibilities; also for innovative solutions (for long-term testing of technologies, etc.). Insurance could set financial incentives, for example, reduced premiums for climate-resilient buildings.			Awareness and acceptance raising by pilots and best-practice examples.	

Table 27: Summary of key barriers and success factors for 'the EU challenge "Apply technical adaptation measures that have limited negative side-effects'

EU CHALLENGE 4: Increase awareness and implementation of nature-based solutions						
	LEVEL OF IMPLEMENTATION	**ECONOMIC /FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
BARRIERS	Effectiveness requires site-specific and locally catered design, necessitating higher consultancy costs than for standard materials.	Scattered evidence, which often lacks long-term cost effectiveness data. High initial construction costs; ongoing maintenance costs.	Lack of government incentives, legislation and standards for green roofs/facades on new buildings *or* conflicts with existing regulations.	Lack of technical know-how (necessitating potentially expensive consultants).	Low acceptance compared to traditional 'grey' infrastructure solutions.	Designing locally adapted nature-based solutions to thrive in climate conditions, while offering

EU CHALLENGE 4: Increase awareness and implementation of nature-based solutions						
	LEVEL OF IMPLEMENTATION	**ECONOMIC /FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
BARRIERS	Competition for use of facades/roofs (for example for electricity generation/ signage/advertising/ media facades).	High cost of retrofitting compared to building new green roofs. Lack of trust in and high scepticism about economic data regarding green roofs and facades. High perceived costs and financial risks of green facades/roofs compared to considered benefits. Securing long-term funding for maintenance.	Lack of integration across sectoral policies, to which green buildings could contribute. Loss of insurance: some insurance companies do not want to cover potential damage to buildings that have made structural changes, like installing green roofs.	Biophysical barriers (not all buildings are suitable for green roofs/retrofitting).	Lack of knowledge, education, and awareness related to potential of green buildings (leading to low support from local authorities and the public). High path dependency in public institutions and hesitation to embrace innovation and/or accept risk	biodiversity co-benefits.
SUCCESS FACTORS	Producing local guidelines and creating	Targeted awareness-raising and	Establishing a tax differentiation system (for example,	Development of technical guides	Informational campaigns to increase	Utilising expert knowledge to

EU CHALLENGE 4: Increase awareness and implementation of nature-based solutions						
	LEVEL OF IMPLEMENTATION	**ECONOMIC /FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
SUCCESS FACTORS	Information-sharing platform for exchange. Providing subsidies or tax breaks for pursuing green buildings.	Information-sharing campaigns. Changing legislation, regulations, standards and planning guidelines. Government financial support for construction costs of green roofs. Sharing of evidence on costs and benefits, ideally stemming from local examples.	reducing water taxes for homeowners with green roofs; or levying stormwater management charges on impervious surfaces) Legal requirement for green roofs (for example on new developments fulfilling certain size criteria, for city-owned buildings, etc.). Supporting programmes to address code and zoning obstacles.	Fostering exchange with successful case studies.	Awareness and highlight effective case studies and diverse co-benefits. Supporting demonstration projects and providing publicly accessible data on costs vs benefits. Promoting partnerships and collaborative design processes.	optimise design, ensuring the delivery of primary and co-benefits.

Table 28: Summary of key barriers and success factors for 'Increase awareness and implementation of nature-based solutions'

2.7 Key EU challenges in the 'Health and well-being' strategic area

1) Integration of health, wellbeing and comfort aspects in legislation and policy instruments associated to renovations

Improving building occupants' health and well-being can be one of the most important drivers for renovations. But health and well-being are often overlooked. Until recently, regulatory and legislative measures have failed to fully integrate health and well-being considerations into building legislation. Despite the identified impacts of the indoor environment on occupants' health, it is often a challenging and complex procedure to isolate and quantify the benefits of health, well-being, comfort and productivity from building renovation. In addition, the lack of synergy and interdisciplinarity between working groups on public health and the building sector has been a crucial barrier in integrating these aspects in legislation.

The revised EPBD heads in the right direction by including elements related to health, comfort and air quality. However, it falls short on information about how to achieve satisfactory indoor environmental conditions.

2) Enforce existing provisions in support of the Indoor Environmental Quality (IEQ)

Despite the existence of EN and ISO standards for indoor environments, there is a lack of harmonised design criteria and IEQ requirements at EU level. This makes it impossible to take a systematic approach to comparing outcomes across all Member States. Even though several EU projects[49] examine tools through which health and well-being can be integrated into regulatory tools, there is no formal and standardised approach to systematise this process. In addition, slow implementation and poor compliance at Member State level and the lack of experts able to combine knowledge on IEQ, health and well-being with energy efficiency expertise, leads to further barriers to enforcing existing provisions on IEQ. Another related challenge is the time-consuming and costly procedure to monitor the indoor environment in buildings.

3) Quantification of health and wellbeing benefits from building renovations and integration in the cost-optimal methodology to boost the renovation rate

Isolation of health and well-being benefits from renovation is challenging and complex. Several approaches have been developed to quantify the expected reductions in building-related illnesses and estimate the associated health benefits from building renovations. Although these approaches do not use a common calculation framework, they can be used as a baseline to develop a more complete and structured method. The lack of interdisciplinarity between working groups in public health and the building sectors is another barrier to the quantification of tangible and intangible health and well-being benefits from building renovations.

The following tables summarise key barriers and success factors for each of the EU challenges above.

[49] https://x-tendo.eu/

EU CHALLENGE 1: Integration of health, wellbeing and comfort aspects in legislation and policy instruments associated to renovation						
	LEVEL OF IMPLEMENTA-TION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGICAL**
BARRIERS	EPBD does not sufficiently include provisions on how health, comfort and air quality can be achieved	Macro-economic impact understudied. Lack of cost-optimised solutions to improve IEQ.	Lack of standardised IEQ-related requirements.	Lack of longitudinal studies in Member States.	Lack of awareness about benefits for citizens and professional s.	
SUCCESS FACTORS	Addition of elements on health, comfort and air quality in legislation.	More macro-economic studies on multiple benefits. Increased investment in technical know-how.	Setting up mandatory requirements in building regulations and public policy instruments.	Supporting research projects with field studies evaluating multiple benefits.	Awareness campaigns, education and training programmes .	

Table 29: Summary of key barriers and success factors for the EU challenge 'Integration of health, wellbeing and comfort aspects in legislation and policy instruments associated to renovation'

EU CHALLENGE 2: Enforce existing provisions in support of the Indoor Environmental Quality						
	LEVEL OF IMPLEMENTA-TION	**ECONOMIC/ FINANCIAL**	**ADMINISTRATIVE/ LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGI-CAL**
BARRIERS	Lack of systematic way of involving and documenting IEQ in existing provisions.	Lack of support from value chain actors to boost the development for larger economic impact. Time-consuming and costly procedure to monitor IEQ. No dedicated financial incentives or grants to improve IEQ in buildings.	Lack of harmonised calculation methodology and IEQ requirements at EU level.	Experts involved in existing provisions to support IEQ are not trained beyond energy efficiency matters (lack of skills).	Resistance of building occupants. Lack of social awareness.	
SUCCESS FACTORS	EN and ISO standards for setting up the criteria exist. A number of EU projects examine tools through which health and well-being can be integrated.	Reduction of high costs of monitoring equipment, software and training of professionals. Extension of existing schemes for energy efficiency to IEQ.		IEQ-focused programmes in existing EU initiatives such as BUILDUP Skills.	Improving public health thanks to healthier indoor environments.	

Table 30: Summary of key barriers and success factors for the EU challenge 'Enforce existing provisions in support of the Indoor Environmental Quality'

EU CHALLENGE 3: Quantification of health and wellbeing benefits from building renovations and integration in the cost-optimal methodology to boost the renovation rate						
	LEVEL OF IMPLEMENTA-TION	**ECONOMIC/ FINANCIAL**	**ADMINISTRA-TIVE/LEGAL**	**TECHNOLOGICAL**	**SOCIAL**	**ECOLOGI-CAL**
BARRIERS	No standardised methodology for quantifying health and well-being benefits from renovation.	The macro-economic impact of energy poverty on health and well-being is understudied. Difficult to translate non-tangible benefits into monetary values or integrate them as financial offsets in renovation planning.		Lack of longitudinal studies across different building typologies on quantification of health and well-being benefits.	Insufficient interdisciplinarity between public health and building sector.	
SUCCESS FACTORS	Methods exists that quantify the expected reductions in building-related illnesses and estimate the associated health benefits.	More and more funding opportunities exist supporting the quantification and monetisation of multiple benefits from building retrofits. Financial gains from increased productivity, lower absenteeism and reduced healthcare.		Initiatives to create new databases from Member States. The existing methods for quantifying benefits can be used as a baseline for developing a more complete and standardised approach.	Reduction of sick days. Increased productivity. Reduced employee turnover.	

Table 31: Summary of key barriers and success factors for the EU challenge 'Quantification of health and wellbeing benefits from building renovations and integration in the cost-optimal methodology to boost the renovation rate'

Bibliography

The bibliography lists the literature we used to carry out the analysis and the relevant EU legislation and documents for each strategic area. It also lists EU documents and legislation, including overarching ones, that are relevant across the different strategic areas.

1. Clean and sustainable mobility

Literature

ACEA (2016), The 2030 Urban Mobility Challenge: ACEA's Contribution.

Agora Energiewende (2019), European Energy Transition 2030: The Big Picture. Ten priorities for the next European Commission to meet the EU's 2030 targets and accelerate towards 2050.

European Environmental Agency (2020), The first and last mile – the key to sustainable urban transport.

European Environmental Agency (2020), Transport and Environment Reporting Mechanism (TERM) – Progress of EU transport sector towards its environment and climate objectives.

FLOW Project (2016), The Role of Walking and Cycling in Reducing Congestion: A Portfolio of Measures, Brussels.

Tomassini et al. (2016), EU financial support to sustainable urban mobility and to the use of alternative fuels in EU urban areas.

EU legislation and documents

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Delivering on low-emission mobility, A European Union that protects the planet, empowers its consumers and defends its industry and workers, COM(2017) 675.

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Together towards competitive and resource-efficient urban mobility, COM(2013) 913 final.

Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure.

2. Digital technology

Literature

Baldini et al. (2019), Digital Transformation in Transport, Construction, Energy, Government and Public Administration, JRC Science for Policy Report, Publications Office of the European Union, Luxembourg, 2019.

Borsboom-van Beurden et al. (2017), Smart City Guidance Package for Integrated Planning and Management, NTNU, June 2017.

IEA (2018), Review of applied and tested control possibilities for energy flexibility in buildings.

Lyons (2019), Digitalisation: Opportunities for heating and cooling, JRC Technical Reports.

Vito et al. (2018), Support for setting up a smart readiness indicator for buildings and related impact assessment.

EU legislation and documents

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Shaping Europe's digital future, COM(2020) 67 final.

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A European strategy for data, 19 February 2020, COM(2020) 66 final.

European Commission (2019), Supporting digitalisation of the construction sector and SMEs, DG GROW.

Regulation (EU) 2019/881 of the European Parliament and of the Council of 17 April 2019 on ENISA (the European Union Agency for Cybersecurity) and on information and communications technology cybersecurity certification and repealing Regulation (EU) No 526/2013 (Cybersecurity Act).

Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation).

3. District approaches

Literature

Block & Baugniet (2019), L'actualité réglementaire dans le domaine du solaire photovoltaïque et du stockage énergétique en Wallonie, presentation February 2019. Available at: http://guider.be/custom/domain_1/image_files/Formation/PV2019/1_EF4_Actualite_reglementaire_Guy_Block_2019.pdf (last accessed 30 March 2020).

German Federal Ministry for Economic Affairs and Energy (2015), Energy Efficiency Strategy for Buildings: Methods for achieving a virtually climate-neutral building stock.

Häkkinen (2018), District-scale energy refurbishment helps to achieve low-carbon targets. Available at: https://vttblog.com/2018/09/14/district-scale-energy-refurbishment-helps-to-achieve-low-carbon-targets/ (last accessed 26 February 2020).

IEA and EBC (2019), Cost-effective Building Renovation at District Level Combining Energy Efficiency & Renewables, Annex 75.

Pahio, 2015. It is more sensible to renovate entire residential districts than individual buildings. Available at: https://vttblog.com/2015/11/19/it-is-more-sensible-to-renovate-entire-residential-districts-than-individual-buildings/ (last accessed 26 February 2020).

Roos (2019), Stroomversnelling blijft veel van warmte verwachten – Hoe warmtenetten meer CO2 reductie kunnen opleveren, Stroomversnelling, April 2019. Available at: https://stroomversnelling.nl/wp-content/uploads/2019/05/Warmtenetten.pdf (last accessed 30 March 2020).

Schlitzberger et al. (2018), Kurzgutachten zur Aktualisierung und Fortschreibung der vorliegenden Wirtschaftlichkeitsuntersuchung sowie zu Flexibilisierungsoptionen, Bericht für das BMWi, April 2018.

Vandevyvere et al. (2019), The trade-off between urban building stock retrofit, local renewable energy production and the roll-out of 4G district heating networks. Available at https://www.energyville.be/sites/energyville/files/position_paper_per_blad.pdf (last accessed 27 February 2020).

EU legislation and documents

Regulation (EU) 347/2013 of the European Parliament and of the Council of 17 April 2013 on guidelines for trans-European energy infrastructure.

4. Engaging transformation and phasing out inefficient buildings

Literature

ECN (2017), De derde succesfactor ontrafeld. Available at: https://projecten.topsectorenergie.nl/storage/app/uploads/public/5cc/c3d/a2d/5ccc3da2dbcb7404142547.pdf (last accessed 30 March 2020)

Esser et al. (2019), Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU, Final report by IPSOS and Navigant for the European Commission.

German Federal Ministry for Economic Affairs and Energy (2017), Green Paper on Energy Efficiency.

IPOS (2018), Uncover the underlying motivations and barriers for energy efficient renovations.

Irish Green Building Council (2019), Overcoming the split incentive barrier in the private rental market, International Case Studies.

The Leeuwarden Declaration (2018), Adaptive re-use of the built heritage: Preserving and enhancing the values of our built heritage for future generations, Built Heritage Conference.

EU legislation and documents

Commission Staff Working Document, impact assessment accompanying the document 'Proposal for a Directive of the European Parliament and of the Council amending Directive 2010/31/EU on the energy performance of buildings', SWD(2016) 415.

5. Financing renovation

Literature

IEA (2019), Perspectives for the clean energy transition. The critical role of buildings.

Energy Efficiency Financial Institutions Group (2015), Final report covering buildings, industry and SMEs.

European Construction Sector Observatory (2018), Stimulating favourable investment conditions, Analytical report.

European Parliament (2016), Boosting Building Renovation: What Potential and Value for Europe? Study for the ITRE Committee. Available at: https://www.europarl.europa.eu/RegData/etudes/STUD/2016/587326/IPOL_STU%282016%29587326_EN.pdf (last accessed 29 May 2020).

EIB (2019), EIB energy lending policy, Supporting the energy transformation. Available at: https://www.eib.org/attachments/strategies/eib_energy_lending_policy_en.pdf (last accessed 30 March 2020).

Joint Research Centre (2016), Synthesis report on the assessment of Member States' building renovation strategies.

EU legislation and documents

European Commission (2014), Technical Guidance, Financing the energy renovation of buildings with Cohesion Policy, Final Report prepared for EC DG Energy.

6. Built environment sustainability and adaptation to climate change

Literature

BAMB (2019), Framework for policies, regulations and standards. Buildings as Material Banks (BAMB) project.

CLIC Project (2020), Circular Models Leveraging Investments in Cultural Heritage Adaptive Reuse. Available at: https://www.clicproject.eu/about/ (last accessed 30 March 2020).

Ebinger & Vergara (2011), Climate Impacts on Energy Systems, Key Issues for Energy Sector Adaptation, World Bank Study.

Ellen MacArthur Foundation (2014), Towards the circular economy Vol. 3: Accelerating the scale-up across global supply chains.

Green Alliance (2015), Unemployment and the circular economy in Europe: a study of opportunities in Italy, Poland and Germany. London, December 2015.

Hertwich et al. (2019), Material efficiency strategies to reducing greenhouse gas emissions associated with buildings, vehicles, and electronics – a review. Environmental Research Letters 14.

Le Den et al. (2017), Insurance of weather and climate related disaster risk: Inventory and analysis of mechanisms to support damage prevention in the EU.

Material Economics (2018), The Circular Economy: a Powerful Force for Climate Mitigation, Transformative innovation for prosperous and low-carbon industry.

Menzies (2011), Embodied energy considerations for existing buildings, Historic Scotland Technical Paper 13, Heriot-Watt University, Edinburgh.

Nußholz et al. (2019), Circular building materials: Carbon saving potential and the role of business model innovation and public policy. Resources, Conservation and Recycling.

Urban agenda partnership on circular economy (2019), Handbook on sustainable & circular re-use of spaces & buildings.

EU legislation and documents

Commission Staff Working Document 'Adapting infrastructure to climate change', accompanying the document Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. An EU Strategy on adaptation to climate change, SWD/2013/0137 Final.

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A new Circular Economy Action Plan for a cleaner and more competitive Europe, COM(2020) 98 final.

Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives.

Green Paper on the insurance of natural and man-made disasters, COM(2013) 213 final.

European Commission (2019), LEVEL(S) – Taking action on the TOTAL impact of the construction sector, available at: https://ec.europa.eu/environment/eussd/buildings.htm (last accessed 30 March 2020).

European Commission (2020), Circular Economy Principles for Buildings Design.

7. Health and well-being

Literature

Al Horr et al. (2016), Impact of indoor environmental quality on occupant well-being and comfort: A review of the literature, International Journal of Sustainable Built Environment.

BPIE (2018), The inner value of a building – Linking indoor environmental quality and energy performance in building regulation.

Dodd et al. (2017), Level(s) – A common EU framework of core sustainability indicators for office and residential buildings: Parts 1 and 2: Introduction to Level(s) and how it works, JRC Science for Policy Report, Publications Office of the European Union.

Environmental Protection Agency (2017), Indoor Air Quality (IAQ), Health, Energy Efficiency and Climate Change.

Joint Research Centre (2017), Promoting healthy and highly energy performing buildings in the European Union.

World Health Organization (2012), Burden of disease from Household Air Pollution for 2012.

EU legislation and documents

Directive (EU) 2019/882 of the European Parliament and of the Council of 17 April 2019 on the accessibility requirements for products and services.

8. EU legislation and documents relevant across strategic areas

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. The European Green Deal, COM(2019) 640 final.

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A Clean Planet for all: A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy, COM(2018) 773 final.

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Sustainable Europe Investment Plan (European Green Deal Investment Plan), 14 January 2020, COM(2020) 21 final.

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A New Industrial Strategy for Europe, 10 March 2020, COM(2020) 102 final.

Commission Recommendation (EU) 2019/786 of 8 May 2019 on building renovation.

Commission Recommendation (EU) 2019/1019 of 7 June 2019 on building modernisation.

Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency.

Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency.

Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable source

Lessons learned to inform integrated approaches for the renovation and modernisation of the built environment

Annex II: Factsheets and lessons learned

ENER/C3/2019-468/03

Written by:
Buildings Performance Institute Europe ASBL (BPIE),
CLIMACT SA,
Creara Consultores SL, and
Ecologic Institute

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Built environment sustainability and adaptation to climate change - Factsheet

Authors: Martin Hirschnitz-Garbers, Jenny Tröltzsch, McKenna Davis (Ecologic Institute)

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Tender N° ENER/C3/2019-468/03

1.1 Introduction

This factsheet provides an overview of how different policy instruments and selected private initiatives can help to achieve European objectives and effectively address key EU challenges in the strategic area of **built environment and adaptation**. The findings draw upon a policy screening for 15 EU Member States, 3 non-EU countries and 5 European regions covering broadly the climatic zones of the EU. In addition, the factsheet draws on additional information provided by external experts as well as on the long-standing expertise of the authors, meaning policy examples going beyond the researched country and region cases are occasionally added. The concluding assessment draws on the findings and detailed analysis of the good practice cases as well as on the in-house expertise of the partners.

1.2 Built environment and adaptation

This area encompasses policies and measures on the built environment relating to a circular economy as well as to climate adaptation and nature-based solutions.

In the EU, the construction industry and building sector is a major user of materials, with buildings accounting for roughly for two-thirds of cement use, more than a third of steel, a quarter of aluminium, and almost a fifth of plastics.[1] When including further building materials, such as bricks, gypsum, lime and copper, Europe's buildings account for roughly 1.6 million tonnes of material use per year. Europe's building stock is expected to slowly expand due to continuing trends of urbanisation and increasing per capita floor space.[2] In addition, most post-war buildings in European Member States will require substantial renovation or replacement in the coming years and decades, not least in relation to energy efficiency standards.[3, 4] Therefore, the sector's material use is expected to increase.

This has consequences for CO_2 emissions associated with the buildings sector because "[…] around 15% of total lifecycle CO_2 emissions from EU buildings today are attributable to materials and construction".[5] Producing these building materials is responsible for approximately 250 million tonnes (Mt) of CO_2 emissions annually, of which cement, steel, aluminium and plastics production account for almost 80%. In a whole lifecycle approach based on a circular economy, a low-carbon building optimises the use of resources and thereby limits carbon emissions during construction, use and end-of-life. Circular economy measures in the buildings sector, such as extending building lifetimes, reusing structural building components, increasing secondary material use, and cement recycling, could reduce emissions by 80 Mt CO_2 a year by 2050. Benefits from increasing circularity in the building sector for carbon savings also form part of the 'Circular Economy Principles for Building Design', which the European Commission together with a wide set of stakeholders from the construction industry developed between 2016 and 2019. The principles

[1] Material Economics (2018). The circular economy – a powerful force for climate mitigation. Transformative innovation for prosperous and low-carbon industry. Stockholm, Sweden. Unless otherwise stated, statistics in this and the following paragraph are taken from this report.
[2] BPIE (2011). Europe's Buildings under the Microscope. A country-by-country review of the energy performance of buildings. Buildings Performance Institute Europe (BPIE),
[3] Ibid.
[4] European Commission (2020). EU Building Factsheets. Last update: May 2020. https://ec.europa.eu/energy/eu-buildings-factsheets_en?redir=1, accessed 16 June 2020.
[5] Material Economics 2018; p.144

encompass general and target-group-specific principles for increasing circularity in the building sector, which encompass fostering durability and adaptability of buildings as well as reducing waste and facilitating high-quality waste management.[6]

European cities are facing mounting pressures from increasing urbanization, compounded by climate hazards such as extreme precipitation, heatwaves, heavy snowfall and rising sea levels. Adaptation measures to increase urban resilience to withstand climate hazards can take the form of technical measures (such as shading devices or planning adjustments such as building design and orientation) as well as nature-based solutions (e.g. green roofs, walls or facades that can regulate temperature variability and buffer precipitation peaks). Both types of measures are essential to incorporate climate impacts within the building sector. Nature-based solutions in combination with buildings also offer co-benefits such as improving air quality, biodiversity, local food production, and aesthetic appeal as well as reducing urban heat island effects, contributing to stormwater management and extending the life of the roof membrane.[7, 8]

Against this background it is essential to foster (1) circular building design, (2) re-use of building materials to use construction materials with low embodied carbon, and (3) sustainable adaptation in the urban environment for increased climate resilience. In order to successfully do so, key challenges need to be tackled:

1) Design sustainable buildings taking into account the lifecycle of materials: Today's commercial and residential buildings are rarely designed for extended use life or for re-use and recycling during deconstruction. Therefore, buildings end up being deconstructed before their functional end-of-life and large quantities of construction and demolition waste (CDW) arise, containing embodied carbon.

2) Foster reuse and recycling of building materials and components: Low prices of virgin construction materials and low value of end-of-life materials discourage deconstruction practices oriented towards re-use and recycling. This reduces the availability and use of secondary construction materials.

3) Apply technical adaptation measures that have limited negative side effects: One key challenge is to increase incentives for implementing technical adaptation measures and thus their uptake in buildings and the built environment. Different available measures have environmental trade-offs, e.g. increasing energy and water demand. Climate-resilient approaches should aim for low negative side-effects.

4) Increase awareness and implementation of nature-based solutions: A key challenge is the lack of awareness of nature-based solutions and their ability to deliver diverse benefits. This is compounded by a lack of technical expertise and a largely absent legal framework of standards, requirements or financial support/incentives to increase implementation and secure long-term funding for maintenance costs.[9]

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[6] European Commission (no publication date). Circular Economy - Principles for Building Design. https://ec.europa.eu/docsroom/documents/39984, accessed 4 August 2020.
[7] COM (2013). Adapting infrastructure to climate change. Commission Staff Working Document, SWD(2013) 137 final, Accompanying the document COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS: An EU Strategy on adaptation to climate change.
[8] Kabisch, C., Stadler, J., Korn, H., Bonn, A. (2016): Nature-based solutions to climate change mitigation and adaptation in urban areas. BfN-Skripten 446.
[9] COM, 2013.

Policy can help tackle these key challenges. In the following sections of this factsheet, we provide:

- An overview and brief analysis of relevant provisions implemented in different countries that address the above key challenges;
- A cursory overall assessment of the effectiveness of different national provisions; and
- Highlights of good practice examples.

1.3 Provisions to address key challenges

This section gives an overview of the policies considered to be most successful at tackling key challenges in the area of built environment adaptation. To operationalise the challenges and allow for quantitative estimations on selected aspects, the country screening looked for provisions including material information and passports, increased use of secondary materials in buildings and adaptation measures in building codes:

- Material information and passports: material passports, building logbooks and other approaches increase transparency and provide information along a building's lifecycle on construction materials and building components used. This facilitates the re-use of building parts and deconstruction for recycling of construction materials, fostering a circular built environment. They help building stocks to be viewed and used as 'material banks.'[10]
- Increased use of secondary materials in buildings: provisions, incentives and quotas (mandatory or voluntary) can increase demand for and use of secondary construction materials (e.g. recycled cement) in buildings, by facilitating or rewarding their use or setting a certain share of secondary materials to be used in a building or building components.
- Adaptation measures in building codes: climate impacts (especially extreme events e.g. storms, flooding, heatwaves) can be integrated in requirements for buildings and the built environment. Approaches should support increased climate resilience of buildings and define recommendations and requirements for e.g. energy-efficient air conditioning or flood protection of buildings (e.g. check valves).

Figure 1 provides an overview of the policy screening. Since countries vary in size, the number of provisions does not necessarily reflect the effectiveness of the policy mix. While the number of provisions found may give an indication of the breadth and diversity of approaches, it should not be taken as the sole indicator for how effective the provisions are for tackling key challenges. One well-designed policy instruments may be more effective than a multitude of less adequate instruments. Therefore, an additional qualitative discussion as well as insights from the good practice analysis are provided in the remaining parts of the paper.

[10] The EU research project 'Buildings As Material Banks' (BAMB) investigated enablers for shifting to a circular built environment. URL: https://www.bamb2020.eu/topics/circular-built-environement/, accessed 4 August 2020.

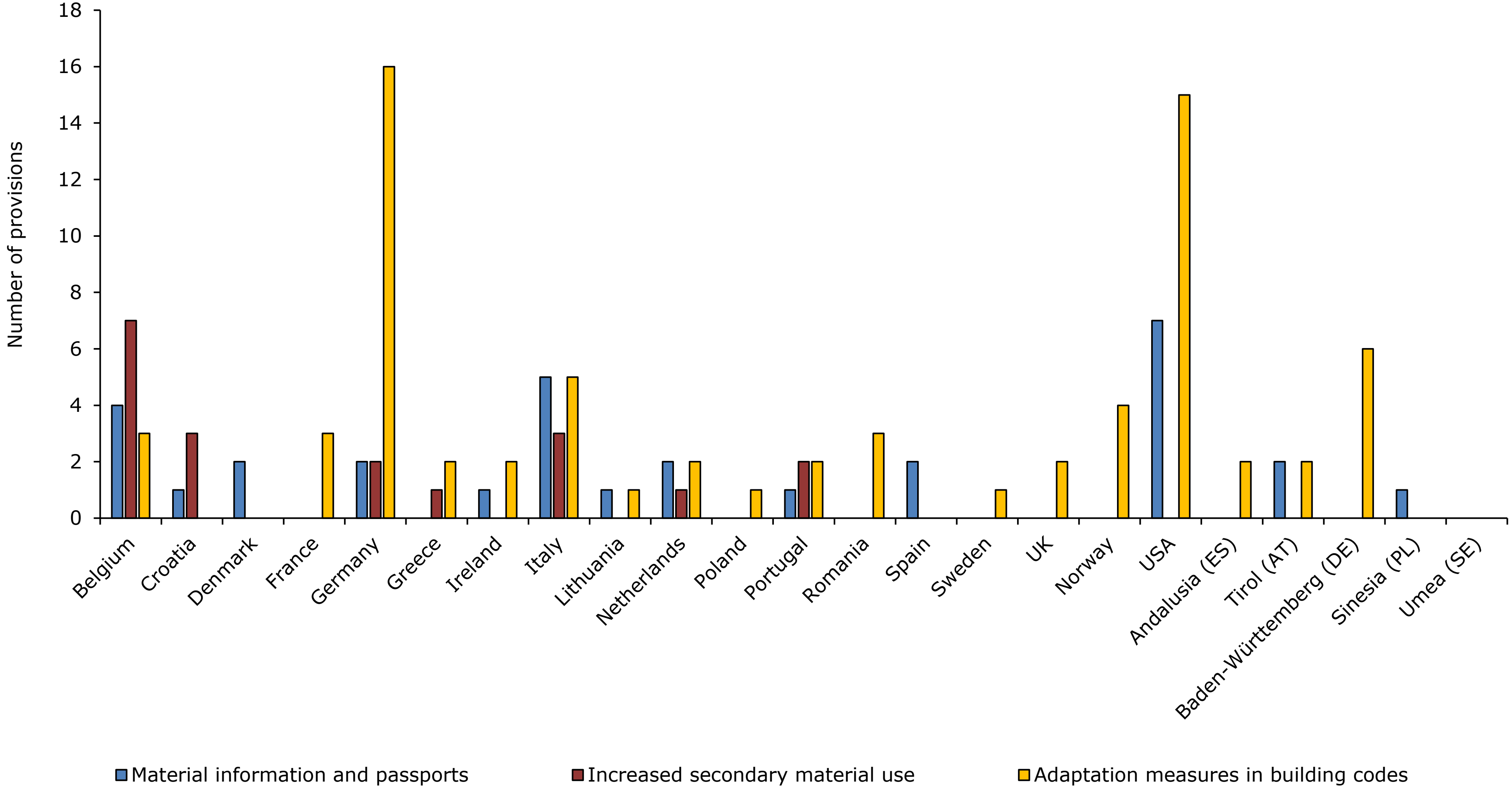

Figure 1 - Key aspects of the built environment and adaptation per country

1.4 Effectiveness of the policy landscape to address key challenges

This section presents an assessment of the overall policy landscape that a previous country screening identified as relevant for the covered countries and regions. The assessment takes into account the diversity of instruments (regulation, pricing, support, information etc.), whether there are particularly interesting and innovative instruments, and whether the instruments identified together seem to be adequate to address the given challenges. The overview tables are followed by a discussion of policy instruments.

In this context, the classification in Table 1 and Table 2 should be interpreted as follows:

Good policy landscape with at least one innovative instrument targeting built-environment adaptation

Adequate policy landscape with instruments that could in the future better integrate built-environment adaptation in building renovation policies

Inadequate policy landscape, with no instruments identified in relation to the given challenges

Not conclusive

Table 1 – Legislative policies

	Built Environment and Adaptation – LEGISLATIVE POLICIES			
	KEY CHALLENGES			
	Designing sustainable buildings taking into account the lifecycle of materials	Fostering reuse and recycling of building materials and components	Apply technical adaptation measures that have limited negative side-effects	Increase awareness and implementation of nature-based solutions
Belgium				
Croatia				
Denmark				
France				
Germany				
Greece				
Ireland				
Italy				
Lithuania				
Netherlands				
Poland				
Portugal				
Romania				
Spain				
Sweden				
UK				
Norway				
USA				

Andalusia				
Tirol				
BW				
Silesia				
Umea				

Table 2 – Non-legislative policies

	Built Environment and Adaptation – NON-LEGISLATIVE POLICIES			
	KEY CHALLENGES			
	Designing sustainable buildings taking into account the lifecycle of materials	Fostering reuse and recycling of building materials and components	Apply technical adaptation measures that have limited negative side-effects	Increase awareness and implementation of nature-based solutions
Belgium				
Croatia				
Denmark				
France				
Germany				
Greece				
Ireland				
Italy				
Lithuania				
Netherlands				
Poland				
Portugal				
Romania				
Spain				
Sweden				
UK				
Norway				
USA				
Andalusia				
Tirol				
BW				
Silesia				
Umea				

1) Design sustainable buildings taking into account the lifecycle of materials

As the production of construction materials is associated with significant greenhouse gas (GHG) emissions, more circular building design can help slow down and reduce the need for new construction materials, and help achieve emissions reductions. Related key challenges are to integrate circularity into existing architectural and engineering education and practices as well as into building owners' and investors' decision-making routines. This requires coordination, dialogue and efforts across building value chains.

Country research shows a diversity of approaches that aim to foster sustainable building design and promote a lifecycle perspective regarding environmental impacts of materials used in construction. Across the differing provisions found at national and regional level, common efforts encompass:

- Increasing the transparency of building material use via the use of material passports and building logbooks (e.g. the manual for future-oriented building projects (GRO) of the Facility Company of the Flemish government in Belgium, the Circle House Lab in Denmark and the Dutch material passport public platform Madaster), standards, manuals and product declarations following lifecycle thinking, all of which facilitate public procurement and implementation of pilot projects. Furthermore, some countries and regions have put in place legal acts promoting climate protection that stipulate applying lifecycle thinking and considering lifecycle costs in public procurement (e.g. section 13 in the Federal Climate Protection Act in Germany and section 7 in the Law for the promotion of climate protection in the German region of Baden-Württemberg).
- Encouraging circularity and long building lifetime in the planning of new buildings, e.g. by adopting legislation that stipulates design for longevity and disassembly legislation (a relevant example is the Decision promulgating the Building Act in Croatia), and improving information flows along with building projects through building information modelling (e.g. the Belgian Tool to Optimise the Total Environmental impact of Materials (TOTEM) and provisions in the National Action Plan for Construction Waste 2017 -2020 of Norway).
- Funding, research and development as well as the implementation of pilot projects for circular building design and reductions in resource use (e.g. the "Circular Construction Challenge" launched by the Danish philanthropic association Realdania) to inspire replication or development of pilot projects elsewhere.

For some countries and regions, the country research yielded no or only very few provisions for tackling the key challenges. In such cases, based on the available information from country research, the policy landscape was considered not conclusive to undertake an assessment (e.g. for the two circular economy-related key challenges this applies to Andalusia, Romania and Lithuania, and for legislative provisions to Denmark and France as well as to the Alpine, Andalusia, Silesia and (partially) Baden-Württemberg regions).

2) Fostering reuse and recycling of building materials and components

Given low demand for secondary construction materials, one of the key challenges is to step up further research and development in the sector to ensure better performing, good quality secondary materials. Furthermore, as building designers, construction material manufacturers, architects and building owners still have many reservations about using secondary materials (also because of uncertainty about their performance, which can create problems in relation to the building warranty), another key challenge is to increase acceptance of and demand for secondary construction materials.

Country research shows a diversity of approaches that aim to foster reuse and recycling of building materials and components. Although differing in their approaches, the provisions identified as relevant have in common the promotion of:

- Use of recycled content and hence of secondary raw materials in buildings
- Circularity in the renovation and reuse of abandoned materials and/or abandoned buildings
- Reductions in the amount of construction waste.

Relevant approaches encompass national plans, legislation and standards that foster and stipulate the use of secondary materials in buildings, in many cases referring to environmental product declarations (e.g. the Sustainable construction evaluation system for federal buildings in Germany). Relevant national plans include, for instance, the government-wide programme for a circular economy in the Netherlands by 2050, the Portuguese Integrated National Energy and Climate Plan 2021-2030 and the Swedish National Waste Management Plan. Regarding legislation, relevant examples include the Decision promulgating the Building Act in Croatia, the German Circular Economy Act and the Polish Regulation of the Minister of the Environment on recycling levels, preparation for reuse and recovery by other methods of certain municipal waste fractions. For standards, e.g. the Italian Decree no. 186 is a relevant example, which implements a standard for the identification of non-hazardous waste for recovery requiring a series of practices to be followed for the recycling and reuse of materials from the construction site, with details including the percentage of recycling allowed for new materials. Several countries have implemented provisions that foster the consideration of environmental criteria in public procurement, which make having environmental information available increasingly important in procurement decisions (e.g. in Belgium, Croatia, Germany, Greece, Italy, the Netherlands, Norway).

New routines and guidelines to facilitate the reuse of building materials or components include pre-demolition inventories as recommended in the EU Construction and Demolition (C&D) Waste Protocol and Guidelines. Such inventories (e.g. a proposal for supervision of the dismantling of buildings and recover deconstruction waste in the Brussels region, in Belgium) oblige applicants for demolition permits to draw up a pre-demolition inventory to list the different waste streams produced on the site and provide a management system, thus encouraging recycling and reuse through better knowledge of the waste produced. In addition, some countries (e.g. Belgium and Croatia) put in place requirements for selective deconstruction, requiring dismantling operations to be organised so that reusable elements are effectively dismantled and recovered for introduction into a reuse chain. However, systematic planning including waste management during the renovation process, as recommended in the EU C&D Waste Protocol, is not yet common practice.

In addition, provisions found for some countries yielded approaches that discourage the use of primary construction minerals, e.g. via a charge on aggregate (sand, gravel and limestone) extraction in the UK (aggregates levy) or a prohibition of setting up a technical landfill for most construction and demolition waste in the Belgian region Wallonia.

Furthermore, information and labelling also help foster increased use of secondary materials in buildings. For example, the Italian brand 'Plastic second life', an environmental product certification system dedicated to materials and products obtained from the recycling of plastic waste, certifies the recycled content and traceability in products. For some countries and regions, the country research yielded no or very few provisions to tackle these key challenges. In such cases, based on the available information from country research the policy landscape was considered inadequate (e.g. for the two circular economy-related key challenges this applies to Andalusia, Lithuania, Romania and Silesia).

3) Apply technical adaptation measures that have limited negative side-effects

The country review highlighted a number of diverse approaches that aim to support the application of technical adaptation measures to increase climate resilience of buildings. Although differing in their approaches, the provisions identified as relevant have in common the promotion of:

- Using and collecting rainwater around buildings, e.g. by cisterns, tanks
- Sun protection and shading on and in buildings
- Efficient water use in and around buildings
- Protection against flooding and landslides
- Providing information and data on local climate impacts (e.g. flood risk) which can be used by municipalities to adjust local approaches.

Reviewed legislative approaches include grants/funding for the construction of rainwater collection (e.g. municipalities within Germany and Baden-Württemberg) and sun protection and shading measures (e.g. Andalucia). Regulations are in place to avoid overheating of buildings, e.g. including technical guidelines (e.g. Ireland, Norway). Technical regulations also concern protection against flooding and landslides (e.g. Norway) and ordinances and technical regulations are in place regarding water conservation and the use of water-efficient products within and around buildings (e.g. USA, Sweden).

Reviewed non-legislative measures include initiatives on providing and promoting information and data platforms highlighting local climate impacts that can guide municipalities in designing legislative and non-legislative measures (e.g. Denmark, Ireland, Norway). Further information platforms are promoting rainwater collection for private homes (e.g. Germany). Guidelines and support programmes are established for climate-friendly construction, protection measures on buildings against extreme events, passive houses including low energy use for cooling (e.g. Germany and Tirol). Certification programmes, rating systems and labels for buildings include water efficiency as a performance category (e.g. USA).

Some measures are designed to reduce possible negative side-effects of adaptation, for example through technical regulations promoting passive cooling and ventilation to avoid additional energy use for air conditioning (e.g. Norway). Conversely, resilience to climate change is occasionally built into technical mitigation measures. For example, the US Department of Energy prepared a note on recommended design specifications for photovoltaic systems to limit hurricane damage. It includes specifications for fasteners but also recommend using modules which have a high rating for front and back load. These additions to technical regulations and standards for photovoltaic systems might be useful in other areas facing high wind speeds.

For a number of countries and regions, there was not enough available information to undertake an assessment.

4) Increase awareness and implementation of nature-based solutions

Country research shows a diversity of approaches to increase awareness and implementation of nature-based solutions. Although differing in their approaches, the provisions identified as relevant have in common the promotion of:

- Constructing green or 'productive' roofs, terraces or vertical walls
- Using ecological materials in work on the envelope of buildings

- Creating open and permeable surfaces to fight against flooding and support water management
- Research to increase the evidence base and create support for nature-based solutions.

Relevant legislative approaches encompass grants/subsidies for the construction of green or 'productive' roofs (e.g. in Belgium, Baden Württemberg and Germany) or terms, conditions and standards (e.g. in Greece, Baden-Württemberg, Germany) that foster and stipulate the use and planting of ecological materials in, on or around buildings (sometimes as part of broader water management strategies, as in Portland, USA).

Non-legislative measures, which were far more prevalent than legislative measures, include initiatives to encourage sustainable architecture, introduce permeable and vegetated services in building renovations or reconstructions (e.g. in Belgium, Germany), foster citizen-led revegetation projects in public spaces (Belgium), increase knowledge and evidence on nature-based solutions through research/pilot projects (e.g. Belgium, Greece, Germany, Netherlands), and raise awareness of nature-based solutions as a tool for e.g. reducing flood risks (Ireland) or sustainable urban development (Germany).

the majority of countries and regions, the research yielded no or very few provisions and was not considered conclusive to undertake an assessment of the policy landscape.

1.5 Highlighting good practice examples

Based on the results of the previous research as well as on expert knowledge, this section highlights selected good practice examples. Each example fulfils one or several of the following selection criteria: innovation (new mechanism, triggering innovation, scaling up innovation), impact (on EU objectives, energy savings, CO_2 emissions reduction, potential renovation impact), ease of implementation (including transferability, scalability, transaction and administrative costs, budget (in-)dependency, compatibility with existing legislative/policy framework) and coverage of diverse jurisdictions and climatic zones.

1) Built environment

Country	Policy	Brief description	Source
Croatia	Building Act (Zakon o gradnji)	• Article 15 of the Building Act (most recent version, in force since 28 December 2019) stipulates that "buildings must be designed, constructed and removed in such a way that the use of natural resources is sustainable, and in particular must guarantee the following: ○ Reuse or recyclability of the building, its materials and parts after removal ○ Durability of the building ○ Use of environmentally friendly raw materials and secondary materials in buildings"	Croatian Parliament

		• Such a legal stipulation to use secondary materials in construction works sets an effective framework to foster circular design and buildings and is rare across the countries analysed.	
Denmark	Circle House Lab	• Multi-stakeholder exchange platform and laboratory for experimenting with circular building solutions across the industry. The knowledge and discoveries from Circle House Lab will be updated and shared on their webpage and in a cloud folder, for everyone to access. • The Circle House Lab aims to accelerate the transition to a circular economy in the Danish building industry by: ○ Developing solutions and standards such as digital building logbooks on selective demolition, design for disassembly and circular construction (adapt the building stock to demographic fluctuations) ○ Providing advice to renew the traditional business models and to ensure that the legislation supports recycling and circular construction. • Tackling the key challenges requires multi-stakeholder dialogue along the building value chain. The Circle House Lab provides a promising platform for such dialogue and for joint progress.	BloxHub
Germany	Circular Economy Act (Kreislaufwirt-schaftsgesetz KrWG)	• Section 45 "Obligations of the public sector" of the Circular Economy Act obliges, among others, authorities and agencies to contribute, through their conduct, including procurement, to promote a circular economy in order to conserve natural resources and to ensure the protection of human health and the environment in the generation and management of waste. For this purpose, they shall examine inter alia in procurement whether products can be used, that are resource-efficient, low in waste, repairable, low-polluting and recyclable. • Green public procurement is a key instrument to push demand for secondary materials in buildings and to build up secondary markets.	BMU
The Netherlands	Transition Agenda Circular Construction	• The transition agenda describes the strategy for achieving a circular construction economy in 2050 and contains specific recommendations	Transition Agenda Circular

	Economy (Transitie-Agenda Circulaire Bouweconomie)	for the period 2018-2021. It was drawn up by a transition team of experts from science, government and market parties. The agenda recommends that: ◦ A decision on the use of a materials passport is made by 2020 ◦ All government procurement must be circular by 2030 ◦ Circular construction should be an integral part of education by 2021 ◦ Circularity is introduced in building codes. • Integrating circular design into building codes and education of building professionals promises long-term effects towards making circular buildings the new default.	Construction Economy
Spain	Demolition Waste National Plan for the period 2016 – 2022 (Plan Estatal Marco de Gestión de Residuos 'PEMAR' 2016-2022)	• The national plan aims to reduce resource use, increase the recycling rate and improve resource efficiency. The plan has a specific chapter targeting construction waste and demolition in order to promote actions for reutilisation and recycling of construction material to ensure that Spain complies with legal EU objectives. • The plan pursues a diversity of objectives and suggests an effective policy mix of, inter alia: ◦ Research, development and innovation regarding the durability and recycling possibility of materials, which will play an important role in achieving EU recycling targets ◦ Increasing taxes (economic disincentives) ◦ Encouraging the use of sustainable products.	Construction and demolition waste management in Spain
UK	Aggregates levy	• The aggregates levy, a tax on sand, gravel and rock which has been dug from the ground, dredged from the sea in UK waters or imported, charges £2 per tonne of sand, gravel or rock. • As aggregates are a key building material, increasing their prices by taxing them provides incentives for using (instead or in addition) secondary materials from domestic sources for construction projects.	UK government

2) Adaptation and nature-based solutions

Country	Policy	Brief description	Source
Germany	Bundesweite Initiativen zur Stadtgrün (Nationwide Initiative – Green in the City)	• The "Green in the City" initiative and the new urban development support programme "Zukunft Stadtgrün" (Future City Green) focus on urban green infrastructure. This means that for the first time there is the possibility of an area-wide promotion of green roofs and facades within the framework of urban development funding.	City of Stuttgart
Ireland	Dublin Climate Action Plan – Nature-based solutions	• The Dublin Climate Action Plan, developed by the Dublin City Council in 2019, includes a chapter on nature-based solutions for adaptation measures. Planned policies include pilot projects for green roofs on civic buildings (awaiting funding), development of a Green Infrastructure Strategy for the region (2021), increasing flood resilience, e.g. implementing sustainable urban drainage guidelines in council buildings, flood awareness campaigns and flood alleviation/ adaptation schemes.	Dublin City Council
The Netherlands	City Deal Klimaatadaptatie (City Deal Climate Adaptation)	• Cooperation agreement between 17 public partners and 17 (semi)private cooperation partners and the central government to implement pilot projects to develop new forms of governance and financing structures and innovative solutions. Two of four focus areas concentrate on climate-robust area development (for public and private parties in development, design, renovation and management); and development and integration of nature-based solutions and ecosystem services (to examine added value and demonstrate feasibility).	City Deal Klimaatadaptatie
USA	City of Portland Green Building Policy	• The City of Portland implemented a Green Building Policy in 2001, which was updated in 2015 with Resolution 37122. The policy obligates new, occupied city-owned buildings to achieve Leadership in Energy and Environmental Design (LEED) Building Design and Construction (BD+C) at the Gold level. They should also include eco roofs and storm water management strategies and related watershed enhancement strategies in their design and provide adequate bicycle parking opportunities (equal to 25% of the target in the City's Climate Action Plan).	City of Portland
Germany	Gräfelfingen support programme for rainwater utilisation	• The municipality of Gräfelfing is promoting the construction of cisterns to collect and use rainwater for garden irrigation and/or service water use. The amount of funding depends on the size of the cistern. Eligible to apply are building owners (private owners, owners' associations), as well as tenants, provided that the landlord's declaration of consent is	Municipality of Gräfelfing

	(Municipality of Gräfelfing)	available. The municipality of Gräfelfing supports the construction of rainwater cisterns, the devices for the supply of rainwater and the necessary installations for the use of rainwater.	
Germany	Information platform for rainwater utilisation in homes	• Information on rainwater use in homes related to financial support, advantages, costs and benefits, basis for calculation.	Homeowners' Association Bavaria e.V.
Denmark	Climate Atlas (Klimaatlas)	• The tool is a nationwide climate atlas based on own data and data from the Intergovernmental Panel on Climate Change (IPCC). Data is free and available on the DMI website. • The Climate Atlas provide an indication of areas with particular risk of storm surge and cloudburst, and thus the risk of flooding in Denmark in the future. This tool gives the climate data so municipalities can take the necessary precautions and guard citizens, infrastructure and buildings against the expected extreme weather in the future.	Danish Meterological Institute (DMI)
Ireland	Building Regulation - Technical Guidance Part L 2019 Building Control Act (1990)	• The Building Regulation on conservation of fuel and energy includes regulations on "Limiting Heat Gains" in residential buildings. ○ 1.3.5.2. Recommendations and guidance to reduce and avoid solar overheating (layout, solar shading, thermal mass, good ventilation).	Building regulation – Technical guidance
Norway	Building Technical Regulations	• The building code prescribes minimum measures that need to be taken in protection against natural stresses (e.g. flooding and landslides). Requirements are linked to the level of risk in the construction area. All buildings are categorised based on functionality. In particular, buildings with high public importance, like police stations, or buildings with vulnerable people, like hospitals and schools, can only be constructed in low-risk zones. Other buildings will get a safety class which defines the risk they may be exposed to in terms of floods. The technical regulation also includes a section on thermal comfort which describes the recommended temperatures, passive measures and opening of windows and doors.	Norwegian Building Authority
USA	WaterSense program	• WaterSense is a voluntary partnership sponsored by the US Environmental Protection Agency (EPA), which labels water-efficient products, new homes and programmes and provides resources on how to save water. For	US Environmental Protection

		WaterSense labelled homes, the following issues are included: ○ Indoor criteria: leaks, service pressure, hot water delivery, plumbing fixtures, dishwashers and clothes washers ○ Outdoor criteria: landscape design, irrigation system, pools and spas.	Agency (EPA)
Tirol	Measures catalogue: Climate-friendly construction	• The measures catalogue includes synergy measures between climate protection, climate change adaptation and living comfort (heat and cold insulation and ventilation concepts), as well as measures to adapt to a changed natural hazard potential (flood protection) and ensure drainage infrastructure can cope with increased rainfall.	Office of the Tirolean Provincial Government Energy Tirol

1.6 Concluding assessment

Assessment of impact per type of policy instrument

For the strategic area "built environment and adaptation", four key challenges have been defined:

1. Design sustainable buildings taking into account the lifecycle of materials
2. Foster reuse and recycling of building material and components
3. Apply technical adaptation measures that have limited negative side-effects
4. Increase awareness and implementation of nature-based solutions.

The country research revealed a variety of provisions and approaches at national and regional level aimed at tackling the above challenges. There is a mix of legislative and non-legislative policies in place to address the first two challenges, but legislative provisions constitute a higher share of provisions relating to the second. The main reason seems to be that increasing re-use of building materials and components fits with existing national and regional building or waste legislation, while approaches for circular building design appear to focus on improved information flows and transparency (for instance via building information modelling) as well as funding for research and development and pilot projects. However, legislative provisions also play a role towards tackling the first key challenge, for instance when stipulating design for longevity and disassembly or via legislation on climate protection, which fosters the integration of lifecycle thinking for low-carbon materials. Alongside information flows and lifecycle thinking, incentives play a relevant role too. Environmental product declarations and labels on circular building materials facilitate green public procurement, where they provide proof that environmental criteria are being fulfilled during procurement. Linking incentives for green public procurement with disincentives, such as prohibiting landfilling of construction materials or charging for extraction of primary aggregates, might form a promising policy mix. Overall, country research findings appear to be in line with key principles highlighted by the European Circular Economy Principles for Building Design.

The identified set of policies constitutes a promising menu to build effective policy mixes for contributing to GHG emission reductions. While regulatory approaches – when combined with effective administration, monitoring and enforcement – form an important baseline to set conducive framework conditions and motivate compliance, economic and fiscal incentives to help create markets and reward circular approaches (or/and penalise linear ones) are equally important in order to foster innovation and support "first movers" in more sustainable markets. As innovation thrives where peer learning takes place, providing room for networking and dialogue across the building sector (and its value chain stages) is essential to enshrine progress towards circular and low-carbon buildings and construction on the supply side. This shows the interconnectedness of different policy instruments: a sound legal basis is needed to provide guidance (e.g. secondary material quotas or enshrining in legislation the obligation to monitor and consider embodied carbon of different materials in building design and procurement) and sanction non-compliance. This in turn helps establish a level playing field across market actors in the building sector. At the same time, specific incentive structures can give circular products and services a competitive edge. This is likely to function best (or only) if all key players are involved and engage in dialogue and joint action based on optimal flows of information. On the demand side, information flows, facilitated by credible labels and certification, enable owners and purchasers of buildings and building services to identify and opt for circular solutions. Adding financial incentives for making the "right" choices will assist consumers in demanding circular approaches. For incentives (e.g. subsidies) to work effectively, they need to be accompanied, inter alia, by product declarations and/or labels in order to enable public and private procurement to clearly identify subsidised products and make use of incentives. Similarly, without regulatory backing, incentives may face legal challenges from market players whose products are not subsidised. Therefore, the potential impact of individual instruments should be assessed as part of a broader strategic policy mix and roadmap that aims to maximise synergies and alleviate trade-offs.

Regarding challenge 3, a number of legislative and non-legislative provisions are established. In most countries a mix of both approaches is in place. Legislative approaches include technical regulations focusing on flooding, landslides, water efficiency and thermal comfort within the building. A good example is the Building Technical Regulation established in Norway, which indicates acceptable local risk level according to the function of the building. Further legislation focuses on mandatory requirements for rainwater collection. Grants, subsidies or supporting programmes in some communities and countries support the implementation of other legislation or are stand-alone instruments. The legislative provisions are partially combined with non-legislative approaches such as information platforms, e.g. on rainwater collection and use for the community in Gräfelfing, or guidelines on implementation of climate-friendly construction, protection against extreme events or sun protection and cooling. Further information platforms and data promote climate impact information, which is necessary to indicate local risk levels for e.g. flood risk. Negative side-effects are addressed by more general approaches, e.g. the concept of passive houses which combine a number of advantages including lower energy use for cooling.

For effective implementation and uptake of technical adaptation measures, a sound mix of policies is essential, especially to avoid potential negative side-effects of a number of technical adaptation measures. Mandatory technical regulations and building codes could have a vital impact on increasing climate resilience of buildings, including e.g. sun-shading, flood protection and water efficiency. They should include a focus on passive houses, passive cooling systems, etc. to limit negative side-effects of increasing energy use mainly due to active air conditioning.

Other aspects are difficult to include in technical regulations as they depend on the individual building's location and local circumstances. For example, adjusting the direction that windows and certain rooms face can be an effective instrument to limit cooling demand, but can only happen through guidance and information for planning and architecture offices and house builders.

Certification programmes and labels cover a number of environmental issues such as water efficiency and reuse, energy efficiency and waste management. They can give positive incentives to include these aspects in building projects. Some examples show that certification and label systems can be included in local regulations and then become mandatory for new houses.

While reducing GHG emissions is not the main objective of technical adaptation measures, well-designed policies should aim to limit the increase of GHG emissions linked to responses such as active cooling systems.

Regarding the challenge of nature-based solutions, only a limited number of national and regional level examples were identified. In the case of Germany, which had the largest number of examples, the majority of measures were legislative in nature and concerned regional or city-level green roof planning instruments. A range of subsidies, grants and planning requirements supported the construction of new green roofs and/or facades as well as the retrofitting of existing buildings. As responsibility for these policies falls in the hands of the regions (Länder), it is not surprising that this is reflected in the assessment. Across the remaining countries and regions, only Belgium had a comparably high number of measures (15). The lack of measures in the remaining regions/countries can possibly be attributed to the chosen focus of research related to nature-based solutions. As this term is relatively new and largely adopted at European but not Member State or regional level, robust searches would also need to include similar sectoral terms such as green (and blue) infrastructure, ecosystem-based adaptation, natural water retention measures, etc. to gain a more holistic picture of the legislative and non-legislative measures being implemented.

Within the last challenge, we focused on increasing awareness with a focus on guidance, information platforms and support programmes to increase awareness and knowledge on nature-based solutions. As is well known, these types of instruments have less direct, more indirect effects on GHG emissions as well as other environmental problems such as heat island effects or urban flood events.

The main target groups for these measures are local public authorities and private and public property owners. Measures need to be implemented at local level, as communities and cities are mainly responsible for local planning processes and need to be aware of benefits including positive side-effects of nature-based solutions. This also means that activities at EU level are limited. A major issue is that nature-based solutions are not well known; they may be associated with increased maintenance costs, or there is low awareness of the the positive side-effects, such as improved air quality, recreational potential and biodiversity. Providing information and increasing awareness is a pre-condition for increasing uptake of local nature-based solutions, which could additionally be supported by financial support programmes, grants, etc.

Ease of implementation per type of policy instrument

Whether or not a policy instrument can (more or less) be easily implemented depends on several contextual factors, some of which public policy can control or influence, while others are independent of it. Within reach of public policy are the capacity and will of political actors and administrations to lay down an ambitious legal base towards a circular and low-carbon built environment, and to provide resources needed to implement and monitor this legal base. Regulations therefore constitute a policy instrument that can be easily implemented, if a country’s political economy is conducive to passing this kind of sustainable legislation. Furthermore, as legislation relating to buildings is in place across all EU Member States, good options to anchor circular building approaches already exist and make passing such laws easier than if built from scratch. The EU’s Waste Framework Directive stipulates national transposition of requirements relating to e.g. reducing construction and demolition waste, so there is existing political momentum, which can open up so-called policy windows in several countries to push for more circular approaches in legislation.

Similarly, financial and fiscal means to incentivise circular approaches, whether through green public procurement (e.g. giving clear guidance and weighting for circularity criteria) or increasing the price for using virgin building materials, can be promoted across countries where both political will and the public budget allow. But while incentives may function relatively independent of context as a policy instrument type, sectoral specificities should be borne in mind when designing incentive levels and the purpose that, e.g. tax income, is used for. Here, setting up tax recycling schemes that channel tax income back to those paying the tax in order to ease their transition to a circular economy can increase acceptance and hence ease implementation. As debates on reduction of VAT for certain circular products and services at EU level show, changing tax schemes EU-wide is a very contentious issue affecting Member States’ fiscal sovereignty and therefore requires unanimous decisions. Hence, achieving tax agreements at EU level may pose a formidable challenge. But EU-level processes, such as the Green Deal and new Circular Economy Action Plan, can foster national-level action – e.g. on financial and fiscal incentives – by providing guidance on general policy orientation towards circular buildings.

Setting up or supporting the set-up of networks and dialogue should be within easy reach of public policy, either by actively using contacts to establish them under public auspices, by providing physical meeting space, or by encouraging and becoming part of processes already set up by private actors. At European level, for instance, the European Circular Economy Stakeholder Platform serves as a network of networks and provides an exchange and meeting place for stakeholders (such as public authorities, businesses, trade unions, consumers, academia and civil society) to share and scale up effective solutions at and across local, regional and national levels.

In general, while the legal basis and incentive structures should be uniform and hence apply across a jurisdiction, adapting sub-legal regulations and administrative procedures to regional and municipal/local contexts appears essential to increase the effectiveness of policy instruments.

Technical adaptation measures could be implemented via technical regulations and building codes. These are within the responsibility of national or regional authorities; implementation depends on e.g. capacities, political will, ongoing policy processes and momentum (windows of opportunities). Recent weather events in many EU Member States mean adaptation policies are currently on the political agenda, with adaptation strategies and actions plan being developed or adopted at national, regional and local levels. It should be possible to integrate instruments linked to the building sector with these. At EU level, the ongoing processes linked to the EU adaptation strategy are an opportunity to encourage national adoption of technical regulations on climate-resilient buildings.

Standards are developed and adopted by standardisation organisations (mainly at national or international level, e.g. ISO, DIN) rather than by governments. The integration of adaptation therefore depends on awareness and interest within these organisations. One way to increase awareness could be to include the topic within national stakeholder and network activities organised by public authorities – in Germany, for example, national stakeholder dialogues have been held for several years, including topics like standardisation for adaptation.

In general, measures at EU level could support the delivery of information and knowledge regarding technical adaptation as well as nature-based solutions. To conserve resources and to increase impact, existing adaptation and biodiversity related portals could be used, e.g. portals such as the European Environment Agency Climate-ADAPT platform, which is used as an information hub for climate change and adaptation.

However, increasing awareness will also require more local or regional networks or dialogue processes. Local communities are responsible for planning processes for buildings and their surroundings: to overcome this challenge, existing city networks such as Covenant of Majors for Climate and Energy or Climate Alliance should be used to raise awareness for adaptation of the built environment and used as multipliers to facilitate the initiation and implementation of local processes.

Clean and sustainable mobility – Factsheet

Author: Katharina Umpfenbach

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2.1 Introduction

This factsheet provides an overview of how different policy instruments and selected private initiatives can help to achieve European objectives and effectively address key EU challenges in the strategic area of **clean and sustainable mobility**. The findings draw upon a policy screening for 15 EU Member States, 3 non-EU countries and 5 European regions covering broadly the climatic zones of the EU. In addition, the factsheet draws on additional information provided by external experts as well as on the long-standing expertise of the authors, meaning policy examples going beyond the researched country and region cases are occasionally added. The concluding assessment draws on the findings and detailed analysis of the good practice cases as well as on the in-house expertise of the partners.

2.2 Clean and sustainable mobility

The transport sector is a large and still rising source of greenhouse gas (GHG) emissions and air pollutants.[11] For transport to contribute fairly to the EU target of cutting GHG emissions by 40% by 2030, drastic changes are required. Car- and lorry-based mobility also has negative impacts on safety, space distribution and quality of life. Better urban design and planning can contribute to more sustainable transport options, including by reducing car travel and shortening daily travel distances or by ensuring that new settlements are oriented to facilitate the use of public transport. Building design can also facilitate more sustainable transportation modes through, for example, providing charging infrastructure for electric vehicles or parking for bikes, including cargo bikes.

New buildings and developments in particular present an opportunity to enable their inhabitants to take up and maintain sustainable mobility patterns. They should contribute to reducing negative external impacts of transport rather than exacerbating them (e.g. through increased urban sprawl). Strictly speaking, this strategic area is unlikely to reduce emissions of buildings per se. Electric mobility may even increase the electricity demand in buildings when residents charge their vehicles at home. At the same time, electric vehicles can also become a useful element in a modern, intelligently managed energy system for a building.

When aiming to harness the potential of buildings to help shift mobility pattern, key challenges are:

- Creating a sustainable city layout
- Making buildings ready for e-mobility
- Securing increasing investments

Creating a sustainable city layout: Today's dominance of the car as the prime mode of individual mobility is not only the result of technological developments but was also enabled by city planners that saw private cars as the dominant mode of transport. A key challenge is to overcome this post-war paradigm and replace it with a vision that puts sustainable options such as walking, cycling and electric vehicles at the centre. Acceptability for new types of mobility is a key concern given that new infrastructures will come at some costs for existing ones, in particular roads and parking for cars. New

[11] Eurostat (2019). Smarter, greener, more inclusive? – Indicators to support the Europe 2020 strategy.

approaches have to be socially balanced; they require convenient alternative transport options and they should be debated and explained extensively.[12]

Making buildings ready for e-mobility: Analysis of potential decarbonisation pathways shows that electrification of transport is one of the most promising avenues for reducing the GHG emissions arising from individual mobility. While electric vehicles remain a niche technology in most EU member states, growth rates are promising. For inhabitants of multistorey buildings, the lack of easily available charging points can be a barrier when deciding whether to shift from a conventional car to an electric one. Providing for charging infrastructure both in and close to buildings is therefore critical to enabling electrification of the transport sector.[13]

Securing increasing investments: An overarching challenge in the interplay of mobility and buildings is finance. Rising rents and property prices are a widespread social concern in European cities that, among other effects, may lead to urban sprawl. Any additional increase in investment required to build new or refurbish existing dwellings to facilitate and promote sustainable mobility options can therefore become a social concern. Smart financing and support instruments are key to developing the infrastructures for tomorrow's mobility needs while protecting social cohesion.[14]

2.3 Provisions to address key challenges

This section gives an overview of the policies considered to be most successful at tackling key challenges in the area of clean mobility. To operationalise the mobility challenge and allow for quantitative estimations on selected aspects, the country screening looked for provisions that would implement Article 8 of the Energy Performance of Buildings Directive (EPBD) 2018 on e-mobility, along with legislation beyond, urban planning instruments and approaches to finance urban planning.

Figure 1 provides a quantitative analysis of those provisions identified in the policy screening. Since countries vary in size, the number of provisions does not necessarily reflect the effectiveness of the policy mix. While the number of provisions found may give an indication of the breadth and diversity of approaches, it should not be taken as the sole indicator for how effective the provisions are for tackling key challenges. One well-designed policy instruments may be more effective than a multitude of less adequate instruments. Therefore, an additional qualitative discussion as well as insights from the good practice analysis are provided in the remaining parts of the paper.

Urban planning is a competence assigned to regional and local authorities in virtually all Member States. National governments can influence outcomes to a varying degree by setting out principles or by providing funding, but most decisions are made at sub-national level. This makes an EU-wide assessment of provisions that aim at creating a sustainable city layout particularly challenging. Even within Member States the variations between measures can be relatively high. For the search term 'urban planning', the number of identified provisions therefore reflects not so much the absolute number of relevant

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[12] Agora Verkehrswende (2017). Transforming transport to ensure tomorrow's mobility.
[13] Velten, E.K., Stoll, T., Meinecke, L. (2019). Measures for the promotion of electric vehicles. Ecologic Institute, Berlin. Commissioned by Greenpeace e.V.
[14] Tomassini, M. et al. (2016). EU financial support to sustainable urban mobility and to the use of alternative fuels in EU urban areas.

provisions in each country or region, but the extent to which country researchers included subnational and local examples in the country data sheet in addition to their main focus on national level measures.

With respect to **charging infrastructure for electric vehicles**, the picture is somewhat clearer. National governments have mostly implemented the obligation included in Article 8 of EPBD on charging points for electric vehicles and ducting infrastructure (to support smart buildings) in national law or plan to do so. Moreover, many countries and regions provide financial support for the installation of charging points – a measure that addresses both the challenge of making buildings ready for e-mobility and the challenge of securing funding for sustainable mobility approaches in the built environment.

By contrast, the country research provided limited results on **funding instruments** that address other issues of sustainable urban planning. However, rather than proving that such instruments do not exist, this may reflect the difficulties of capturing such a multi-faceted issue through a country screening making use of only a couple of keywords applied across all countries and regions under study.

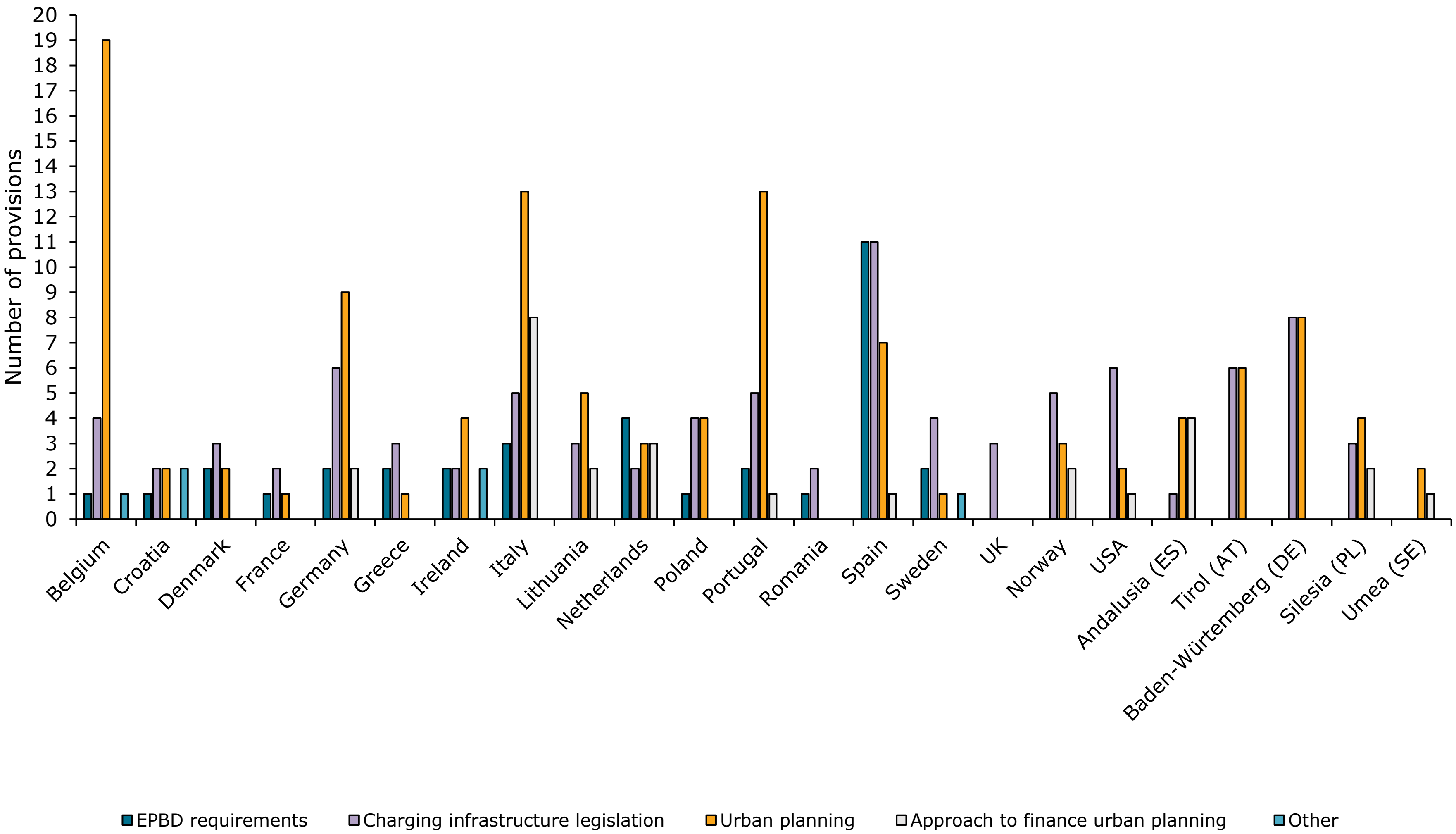

Figure 1 – Key aspects of clean and sustainable mobility per country

2.4 Effectiveness of the policy landscape to address key challenges - overview and description

This section presents an assessment of the overall policy landscape that a previous country screening identified as relevant for the covered countries and regions. The assessment takes into account the diversity of instruments (regulation, pricing, support, information etc.), whether there are particularly interesting and innovative instruments, and whether the instruments identified together seem to be adequate to address the given challenges. The overview tables are followed by a discussion of policy instruments.

In this context, the classification in Table 1 and Table 9 should be interpreted as follows:

	Good policy landscape with at least one innovative instrument targeting clean mobility
	Adequate policy landscape with instruments that could in the future better integrate clean mobility in building renovation policies
	Inadequate policy landscape, with no instruments identified in relation to the given challenges
	Not conclusive

This chapter provides a deeper analysis of the results of the country research with respect to mobility. In particular, it provides more detail on the types of instruments used for tackling the three key challenges: 1) creating sustainable city layouts, 2) making buildings ready for e-mobility, and 3) securing increasing investments.

Overall, the majority of instruments identified in the mobility area are legislative measures, portrayed in This section presents an assessment of the overall policy landscape that a previous country screening identified as relevant for the covered countries and regions. The assessment takes into account the diversity of instruments (regulation, pricing, support, information etc.), whether there are particularly interesting and innovative instruments, and whether the instruments identified together seem adequate to address the given challenges. The overview tables are followed by a discussion of policy instruments.

The given classification in Table 8 and Table 9 should be interpreted as follows:

	Good policy landscape with at least one innovative instrument targeting financing renovation
	Adequate policy landscape with instruments that could in the future better integrate financing in building renovation policies
	Inadequate policy landscape, with no instruments identified in relation to the given challenges
	Not conclusive

Table 8. This clearly results from a research focus on national-level action. At the regional and local level, information-based measures, best-practice sharing and support through handbooks also play a key role.

Table 3 – Legislative policies

	Mobility – legislative policies		
	KEY CHALLENGES		
	Creating a sustainable city layout	Making buildings ready for e-mobility	Securing increasing investments
Belgium			
Croatia			
Denmark			
France			
Germany			
Greece			
Ireland			
Italy			
Lithuania			
Netherlands			
Poland			
Portugal			
Romania			
Spain			
Sweden			
UK			
Norway			
USA			
Andalusia			
Tirol			
Baden-Württemberg			
Silesia			
Umea			

Table 4 – Non-legislative policies

	Mobility – non-legislative policies		
	KEY CHALLENGES		
	Creating a sustainable city layout	Making buildings ready for e-mobility	Securing increasing investments
Belgium			
Croatia			
Denmark			
France			
Germany			
Greece			
Ireland			
Italy			
Lithuania			
Netherlands			
Poland			
Portugal			
Romania			
Spain			

Sweden			
UK			
Norway			
USA			
Andalusia			
Tirol			
Baden-Württemberg			
Silesia			
Umea			

1) Creating a sustainable city layout

Urban planning for sustainable cities and neighbourhoods is a complex issue. While local authorities are central players in charge of planning processes, decisions require coordination with regional and in some cases national governments and with stakeholders including private actors such as developers or transport operators. Moreover, urban planning for sustainable mobility has many dimensions and the importance of each dimension always depends on local conditions. Key issues include, inter alia, mixed neighbourhoods that provide room for living, working and shopping so as to reduce the need for long daily trips; accessibility and attractiveness of public transport; cycling infrastructure; management of parking space; availability of charging points for electric vehicles; availability of convenient car and bike sharing options; management of goods deliveries; and ease of inter-modal trips, i.e. the change between public transport and cars or bikes within one trip.

This new vision of a sustainable city layout has been labelled the 15-minute-city. The term has been used by Anne Hidalgo, the mayor of Paris, in her re-election campaign. It describes the goal that each resident can cover all basic needs with a bike or walking trip of 15 minutes or less. Basic needs include working, education, experiencing nature, shopping, leisure activities like sports, cultural events and social gathering, and medical care. The new paradigm has been taken up by the C40 Cities in their agenda for a green and just recovery from the Covid-19 pandemic.[15]

The country research shows that many countries have overarching plans for green urban planning enshrined in legislation (e.g. Belgian regions, Greece, Croatia, Italy, Ireland, Portugal and Poland). Italy for example aims to reduce the need for transport and increase the sustainability of each trip by promoting smart working, car sharing, the use of public transport and the adoption of efficient vehicles and alternative fuels. Wallonia and Brussels in Belgium have developed innovative principles for planning new neighbourhoods that address the many facets enabling a settlement to become sustainable in an integrated fashion. Wallonia has also developed a tool to design "peaceful neighbourhoods" that focuses on parking space management, aiming to encourage inhabitants to move away from the private car.

While an overarching vision for sustainable transport is crucial, it needs to be combined with concrete actions at the local level. The limited scope of the country research does not allow a final verdict on whether this is happening in each country. As mentioned above, the relevant assessment level is the local municipality. Variations between cities and towns are likely to be significant even within countries. We therefore focus on highlighting good practices with the potential for replication within countries and in other EU Member States.

For the particular issue of cycling, the country research reveals that some countries and local authorities are implementing very concrete regulations. For example, regulations requiring secure bike parking spots for new residential buildings were found in Germany (mandated at the regional level, e.g. Baden-Württemberg) and Tirol as well as in Denmark and in France where the obligation extends to non-residential buildings as well. Some national or regional governments financially support cycling investments at local level

[15] C40 Mayors (2020). Agenda for a green and just recovery, p. 30.

(Baden-Württemberg, Germany). Non-legislative measures include guides on local cycling action plans or best practice sharing between local authorities (Baden-Württemberg).

2) Making buildings ready for e-mobility

The EPBD requires the installation of charging points in certain public parking spaces and sets pre-tubing requirements that allow for subsequent installation of charging points in new or renovated residential buildings of a certain size (as well as for non-residential buildings). Most countries under review in this study have already implemented this regulation or are planning to do so.

The country analysis also shows that many national governments provide grants for private actors who install charging infrastructure in buildings and car parks (e.g. Andalusia, Baden-Württemberg, Ireland, Italy, Sweden, UK, Tirol) or streets (e.g. Portugal, Germany, Poland, Tirol, Sweden). Other countries use tax rebates to support the installation of privately owned charging infrastructure (Denmark, Italy). Denmark also offers tax rebates on the electricity used for charging electric vehicles at home. The Dutch government offers low-rate loans for co-owner associations to finance the installation of charging infrastructure in their building.

The Netherlands has also developed an interesting non-legislative approach using local cooperation agreements between the local government and private sector to ensure minimum and accessible charging infrastructure in business parks. In the US, efforts in several states are focused on establishing charging points in public buildings.

Many countries support the roll-out of charging infrastructure by clarifying technical and regulatory issues, e.g. relating to the roles of different actors and their interaction as well as rules on tariffs (Portugal), safety regulations (Norway), enabling distribution grid operators to manage the impacts of electric mobility on grids (Flanders, Belgium) and connection capacity (Poland). France and Norway have established new rules that make it easier for single owners in collectively owned apartment buildings to install charging points.

Finally, the Nordic countries have established the database NOBIL which provides a map of existing charging points and their accessibility, including those charging points in public and residential buildings.

3) Securing increasing investments

The country researchers have found relatively few examples of financing instruments for sustainable redesign of urban areas – beyond fiscal incentives for electromobility charging infrastructure. This may in part reflect that the issue is hard to describe with a few keywords that can work across all Member States and regions. However, it could also point to a lack of suitable ideas on how to tackle these key issues. As the factsheet on district approaches shows, district or neighbourhood-level projects have the potential to increase the attractiveness of investments thanks to project aggregation and distributed risk portfolios. The larger scope can enable new business models and financing solutions.[16]

[16] Paiho, S. (2014), *Energy-efficient renovation of residential districts*, p.58

The identified examples include a programme in Italy where the national government offers municipalities co-funding for mobility projects that limit traffic and pollution, including cycling projects, walking initiatives, car-pooling, car-sharing, bike-pooling and bike-sharing, education programmes and road safety, and mobility management schemes at universities, schools or other public bodies.

The German development bank KfW offers loans of up to €150 million per year for model projects of so-called "Smart Cities". The low-interest loans can be used for investments in urban development and digitisation. Specific measures include investments in traffic relocation, biking, walking and public transport.

2.5 Highlighting good practice examples

Based on the results of the previous research as well as on expert knowledge, this section portrays selected good practice examples. Each example fulfills one or several of the following selection criteria: innovation (new mechanism, triggering innovation, scaling up innovation), impact (on EU objectives, energy savings, CO_2 emission reduction, potential renovation impact), ease of implementation (including transferability, scalability, transaction and administrative costs, budget (in-)dependency, compatibility with existing legislative/policy framework) and coverage of diverse jurisdiction and climatic zones.

Country	Policy	Brief description	Source
Belgium – Wallonia & Brussels	Establishment of multi-modal stations called "Mobipoles"	• The "mobipoles" will offer various services and allow modal exchange for people, including car parks, in particular car-pooling, secure bicycle shelters, bus, tram, new rapid bus lines, perfectly connected co-working spaces, shared bicycles and cars, charging stations, etc. • Mobipoles aim above all to promote "smart mobility", i.e. a system that includes both sustainable, efficient and innovative solutions and mobility behaviours. • The provision is innovative, because it enables inter-modal trips on the ground, recognising that a shift away from the car will only happen if trips with other modes of transport are convenient for all users (including suburban commuters).	NECP Belgium, p.188.
Belgium – Wallonia	Regional Mobility Strategy	• Aiming to reduce urban sprawl, the strategy prioritises centrality, density and diversity of activities in urban planning. Traffic and parking must be managed in such a way as to reduce the space occupied by cars and give priority to public transport and soft modes where congestion is an issue. The mix of functions must be privileged. These ambitions require coordinating mobility strategies and land-use development. • The action is broken down into concrete multi-year action	Stratégie Régionale de Mobilité Volet I – Mobilité des personnes

		programmes. Mobility issues are to be integrated from the design of new districts or new projects (pedestrian routes to public transport stops, pooling of parking and deliveries, needed space for public transport terminals or depots). • The provision is a good practice example because it combines a vision with well-defined principles of sustainable urban planning with concrete action and concrete projects. It also allows for regular updates and thus policy learning in the process.	
Portugal	NECP measure 1.6 on Decarbonization of cities	• Aims to put cities at the forefront of sustainable mobility, creating conditions for a paradigm shift in urban mobility. Action measures: Mobility and Transport Plans (PMT) or Action Plans for Sustainable Urban Mobility (PAMUS) by municipalities with more than 50,000 inhabitants; demand management (passengers and goods) and urban planning in order to reduce the volume and the distance of travel; tools to support intelligent management of mobility; urban design that favours pedestrians; inter-municipal cooperation. • The strategy is a good practice example because it builds on the understanding that urban planning for sustainable mobility requires a paradigm shift which will only be successful if it is integrated in all dimensions of planning and operating. In particular the focus on inter-municipality cooperation is key for success.	NECP Portugal
Denmark	Local mandatory norms on bike parking	• Minimum requirements for the establishment of bicycle parking facilities when expanding or refurbishing existing buildings: workplaces/educational institutions: 0.5 per person; shopping centres: 4 per $100m^2$; residential blocks of flats: 4 per $100m^2$ • The provision is a good practice example of a concrete mandatory norm that ensures that cycling, as a preferred mobility option for inhabitants and building users, is fully integrated into the building planning approach at an early stage.	Cycling Embassy Denmark
Baden-Württemberg	Information hub for promotion of cycling	• With this information hub on all matters relating to cycling, the regional government provides up-to-date information to its municipalities covering the following areas: legal	Ministry of Transport

		provisions, financing, guidebooks, best practice examples, statistics and ideas for communication strategies. • This provision is an example of support instruments that national or regional governments can use to help local municipalities make progress on cycling.	
Germany	Low-interest loan for municipalities	• Low-interest loan to foster sustainable development of the municipal infrastructure, including traffic relocation through cycling, walking and public transport • This provision addresses a key hurdle for progress at the local level: lack of capital for infrastructure investments (this is particularly the case in municipalities with high debt levels). It is another good example of support from the national level helping municipalities to address sustainable mobility.	KfW

2.6 Concluding assessment

Assessment of impact per type of policy instrument

For the strategic area "clean and sustainable transport", three key challenges have been defined:

- Creating a sustainable city lay-out,
- Making buildings ready for e-mobility
- Securing increasing investments.

The country research shows that a variety of provisions exist that address urban planning and charging infrastructure for e-mobility. By contrast, it has been more difficult to identify provisions targeting broader financing issues (rather than instruments focusing on particular investments such as charging points or cycling infrastructure). The "district approach" strategic area highlighted the potential of neighbourhood or district-level projects to attract investments more easily thanks to project aggregation and distributed risk portfolios. The larger scope can enable new business models and financing solutions (see "district approach" factsheet).

Overall, the majority of instruments identified in the mobility area are legislative measures. This clearly results from the research focus primarily targeting national-level action. On the regional and local level, information-based measures, best-practice sharing and support through handbooks also play a key role.

With respect to the challenge of creating a sustainable city layout, the effectiveness assessment faces the challenge that urban planning is a competence assigned to regional and local authorities. As a result, national-level measures are mostly supportive or guiding while local authorities take the final decisions. This leads to a high variation even within Member States, with some cities effectively tackling the sustainable mobility challenge and others neglecting the issue.

The analysis does nonetheless show that ambitious national and regional governments guide local action by developing overarching visions for sustainable urban areas and setting out key principles such as the need to mix functions, to ensure access to public transport, to reduce public space devoted to car traffic and to build attractive cycling and walking infrastructure. New paradigms such as the vision of a 15-minute city can help build the momentum for local action. Even though overarching visions cannot in and of themselves reduce emissions, they have a key function in communicating the goal of single measures, some of which, like removing car parking spots, can be unpopular with parts of the electorate.

The most comprehensive approaches combine an overarching vision with concrete actions on the different dimensions, e.g. by mandating minimum bike parking spots to be provided at new or renovated buildings, providing financial support or limiting car parking spots in new buildings. These approaches tackle the problem of multi-level governance head on by recognising that effectiveness will require strong vertical and horizontal cooperation between national, regional and local governments and among neighbouring municipalities or regions. As Wallonia's strategy shows, an effective approach requires setting up new governance structures that allow for ongoing target-setting, planning, implementation, review and adaptation. Best practice examples also include national or regional funding to support local authorities to boost sustainable transport through integrated planning. This can take the form of funding for integrated mobility plans or cycling strategies or include practical guides for local authorities on legal, financial and technical questions of implementation.

Given the complexity of changing city layouts for enabling sustainable mobility, all of the actions above are required for substantial change to take place. Taking into account the speed that is needed for this transformation due to the imminent climate crisis and the long investment cycles in buildings, roads and other city infrastructure, there is a clear case for mandatory elements, e.g. with respect to bike parking in new or renovated buildings. Such an approach can avoid costly retrofits at a later stage. Moreover, it is itself a contribution to paradigm shift since it establishes a "new normal" and forces all planners, architects and municipal administrators to familiarise themselves with the infrastructure needs for sustainable mobility.

The picture is more homogenous for the second challenge of making buildings ready for e-mobilty. A key reason is that the EPBD sets EU-wide standards in this field which are implemented at the national level. In addition, most countries under review here provide financial support for private actors who install charging points for electric vehicles. In addition, many Member States have put in place provisions that lay down technical and regulatory standards for the installation and operation of charging points – a key issue for ensuring investment security. The EU-level approach has forced all national governments to address the issue and build knowledge and financial capacity for implementation. What remains to be seen is how stringently enforcement can be monitored at local level.

Ease of implementation per type of policy instrument

The level of awareness of the role of infrastructure in enabling sustainable urban mobility varies widely between and within Member States. As a consequence, some instruments can be easily implemented in one city, but may be perceived as not feasible in another.

In the face of such heterogeneity, strategy and planning tools appear particularly useful, because they can allow each country, region and municipality to assess its starting point and formulate steps forward from there. Ease of implementation will depend on internal capacity and knowledge about the issue in each administration. Therefore, a national or EU approach urging regions and municipalities to draft sustainable mobility plans, while at the same time offering financial support and capacity building, appears promising to drive progress in addressing the challenge of sustainable mobility. Such an approach should include minimum requirements for mobility plans. They should define an overarching vision, set quantitative goals and in-between milestones, define short-term actions and include issue-specific indicators to track progress. Moreover, planning should allow for participation of citizens and stakeholders as well as coordination with neighbouring regions and communities. Finally, each strategy or plan needs to be reviewed and updated at regular intervals.

With respect to implementation measures, mandatory standards (e.g. requiring bike parking spots in new buildings) are promising in terms of overall effectiveness. The EU-level requirement for e-mobility readiness has forced all national governments to address the issue. Mandatory approaches often face political push-back due to cost and feasibility concerns. However, once in place, the scaling effect due to the high number of builders and developers forced to comply can quickly improve ease of implementation as everyone gets familiar with the technology, integrating it into planning processes from the start. Experiences from Denmark and the Netherlands, where bike-friendly infrastructure has a long history, support this assessment.

Digital technologies for energy efficiency and renovation – Factsheet

Authors: Julien Pestiaux, Benoît Martin

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3.1 Introduction

This factsheet provides an overview of how different policy instruments and selected private initiatives can help to achieve European objectives and effectively address key EU challenges in the strategic area of **digital technology**. The findings draw upon a policy screening for 15 EU Member States, 3 non-EU countries and 5 European regions covering broadly the climatic zones of the EU. In addition, the factsheet draws on additional information provided by external experts as well as on the long-standing expertise of the authors, meaning policy examples going beyond the researched country and region cases are occasionally added. The concluding assessment draws on the findings and detailed analysis of the good practice cases as well as on the in-house expertise of the partners.

3.2 Digital technology

Digital technologies can be used and applied across the lifecycle of buildings from design and construction to the building use phase. Digitalisation is a key enabler of building stock decarbonisation in the renovation phase. First, it has a great potential to increase the quality and scalability of solutions, improving design and renovation (e.g. building information modelling [BIM], automation, 3D printing), execution (e.g. digital collaboration platforms), and updated operation and maintenance (e.g. building automated management systems, controllable devices and smart appliances, data collection). Second, by enabling smart and flexible energy services for building users, it allows the development of demand-side management strategies that help to further integrate variable and decentralised renewable energy sources in the energy system.

There are a number of key drivers and trends relevant for the area. The Internet of Things is connecting an increasing number of appliances and services to the internet; this allows remote management, notably in buildings. Many cities have developed local energy plans that aim to organise energy supply in a smart, sustainable yet secure way, for example by creating smart grids. The growing integration of renewables in the system means that matching production with consumption cannot happen solely on the production side, and demand-side measures are increasingly contributing to the flexibility effort.

Digitalisation has an impact on the overall targets for the EU building stock. It helps to optimise energy use for renovated buildings, reducing energy bills, and opens the way for new business models reaping the potential of digital technologies to facilitate the low-carbon transition. It is a key enabler for making use of buildings' flexibility to integrate more low-carbon variable energy sources. Industrialised solutions enabled by digital technologies will help to reduce construction and demolition waste. Digitalisation of buildings also allows and supports better access to and collection of relevant data, including energy data.

The following challenges have been identified as key for the strategic area of digital technology:

1) Unleash the flexibility potential of energy uses via digitalised energy-consuming appliances and services

1a) Foster local consumption of decentralised and variable energy sources.

1b) Support the global energy system with flexible energy consumption patterns.

With a growing penetration of intermittent sources in the production mix, flexibility is more and more needed on the consumption side. While mature business models already exist for large-scale flexibility harvesting (e.g. industry), the key challenge is to harvest small-scale flexibility, e.g. at residential level. Digitisation is key in this process and in keeping the cost of the energy transition under control.

2) Mainstream optimal energy uses via digitalised energy-consuming appliances and services

Optimising energy use through digitalisation helps reap the full benefits of deep renovations; self-regulating devices limit unnecessary energy use and help address technical failures that could lead to additional energy consumption. However, the mainstreaming of digitalisation techniques to enable smart buildings is hampered by split incentives (buildings owners that do not directly occupy their buildings have no direct incentive to increase energy performance by installing self-regulating devices) and the cost of digitalisation for building technical systems.

3) Digitalise the buildings renovation supply chain

The whole construction ecosystem can benefit from digitalisation, e.g. by using BIM that allows increased collaboration during construction, transparency and trust; when used during operation, BIM can help optimise the building's management, reducing energy and overall resource consumption. However, there are many barriers to the complete uptake of BIM such as lack of investment, lack of trained employees, lack of software (often due to cost) and data security considerations.[17]

4) Digitalise data collection about the building stock across Europe

There is an increasing amount of data on building energy use and building occupants' energy consumption patterns. Collecting this data and making it available in a transparent way would be useful both for policymaking and to support the creation of innovative energy services and business models. To this end, the key challenge is to create a framework that systematises data collection by allowing the integration of data from different sources (for example smart meters or energy performance certificate repositories) and the automation of the process with minimal manual intervention. In addition, digitalisation of data collection should ensure compliance with data protection regulation and broadly ensure digital security.[18]

3.3 Provisions to address key challenges

This section gives an overview of the policies considered to be most successful at tackling key challenges in the area of digital technology. To operationalise the challenges and allow for quantitative estimations on selected aspects, the country screening looked for provisions that foster local electricity consumption, increase the flexibility of consumption patterns, and support digitised energy-consuming appliances, supply chains and data collection.

Figure 1 provides an overview of the policy screening. Since countries vary in size, the number of provisions does not necessarily reflect the effectiveness of the policy mix. While

[17] European Commission (2010). Supporting digitalisation of the construction sector and SMEs – Including Building Information Modelling

[18] Challenge expressed by the Commission in its H2020 call "European building stock data 4.0". https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/lc-sc3-b4e-7-2020

the number of provisions found may give an indication of the breadth and diversity of approaches, it should not be taken as the sole indicator for how effective the provisions are for tackling key challenges. One well-designed policy instruments may be more effective than a multitude of less adequate instruments. Therefore, an additional qualitative discussion as well as insights from the good practice analysis are provided in the remaining parts of the paper.

The first two key challenges listed above are also mentioned in the newly adopted Energy System Integration Strategy. In this strategy, the digitisation of the energy system is seen as way to interlink energy carriers more easily, match production and consumption at smaller scale, maximise the autoconsumption of energy and unleash the full flexibility potential of final customers in order to ease the integration of more renewable energy. In order to do so, one key initiative of this strategy directly linked to the digitisation of residential and tertiary buildings is *"to develop a Network Code on Demand Side Flexibility to unlock the potential of electric vehicles, heat pumps and other electricity consumption to contribute to the flexibility of the energy system (starting end-2021)."* This EU-level standardisation initiative is an important step towards large-scale harvesting of small-scale flexibility.

At national and regional scale, 18 countries and 5 regions were checked for the relevance of their provisions concerning digital technology. This covers a wide range of measures, including, e.g. initiatives, project funding, knowledge creation, incentives and legislation, and estimates their impact on the above five key challenges related to digital technology and its role in the transformation of buildings across Europe. The impact of the provisions on the key challenges is scored from 1 to 3; only provisions scoring 2 and 3 are counted and represented in Figure 2 below, with the provisions scoring 2 given half the weighting of those scoring the maximum of 3 points.

The assessment shows a very contrasting picture, with policies encouraging the use of digital technology being implemented at very different levels across EU Member States and the other countries and regions covered. Two Member States (Germany and Spain) already have a large set of relatively comprehensive policies with more than 15 provisions identified to cover all five key challenges. Portugal stands out as well, with two key challenges covered by more than 15 provisions and two others with 10 provisions or more. Then follow two groups of countries with fewer provisions : a group of ~10 countries/regions with mostly 5-10 provisions per key challenge, and a last group of ~10 countries/regions with about 0-5 provisions for each key challenge.

Taking the average across Europe shows that the two key challenges with the fewest provisions are 1a (Foster self-consumption and locally produced energy) and 3 (Digitalise the buildings renovation supply chain).

1a) Foster local consumption of decentralised and variable energy sources: there are many provisions in place in Germany and Spain, and another couple of countries have close to 10 related provisions (Poland and Sweden). Most other countries are below five provisions.

1b) Support the global energy system with flexible energy consumption patterns: this is one of the strongest dimensions represented, with many countries having implemented impactful measures. Germany, Spain and the UK stand out here.

2) Mainstream optimal energy uses via digitalised energy-consuming appliances and services: this dimension has a high average of nine related provisions. Beyond

Germany and Spain, where more than 25 provisions touch upon it, Portugal stands out as well as Denmark and Sweden.

3) Digitalise the buildings renovation supply chain: this is slowly taking off, with an average of six provisions per country/region. A lot of work is also taking place in this respect at the European level to push for more advanced tools in the buildings sector, although this wasn't the focus of the present work.

4) Digitalise data collection about the building stock across Europe: Portugal, Germany and Spain stand out with 18 or 19 provisions touching upon this topic, but this dimension is relatively evenly covered across Members States with an average of nine provisions per country/region.

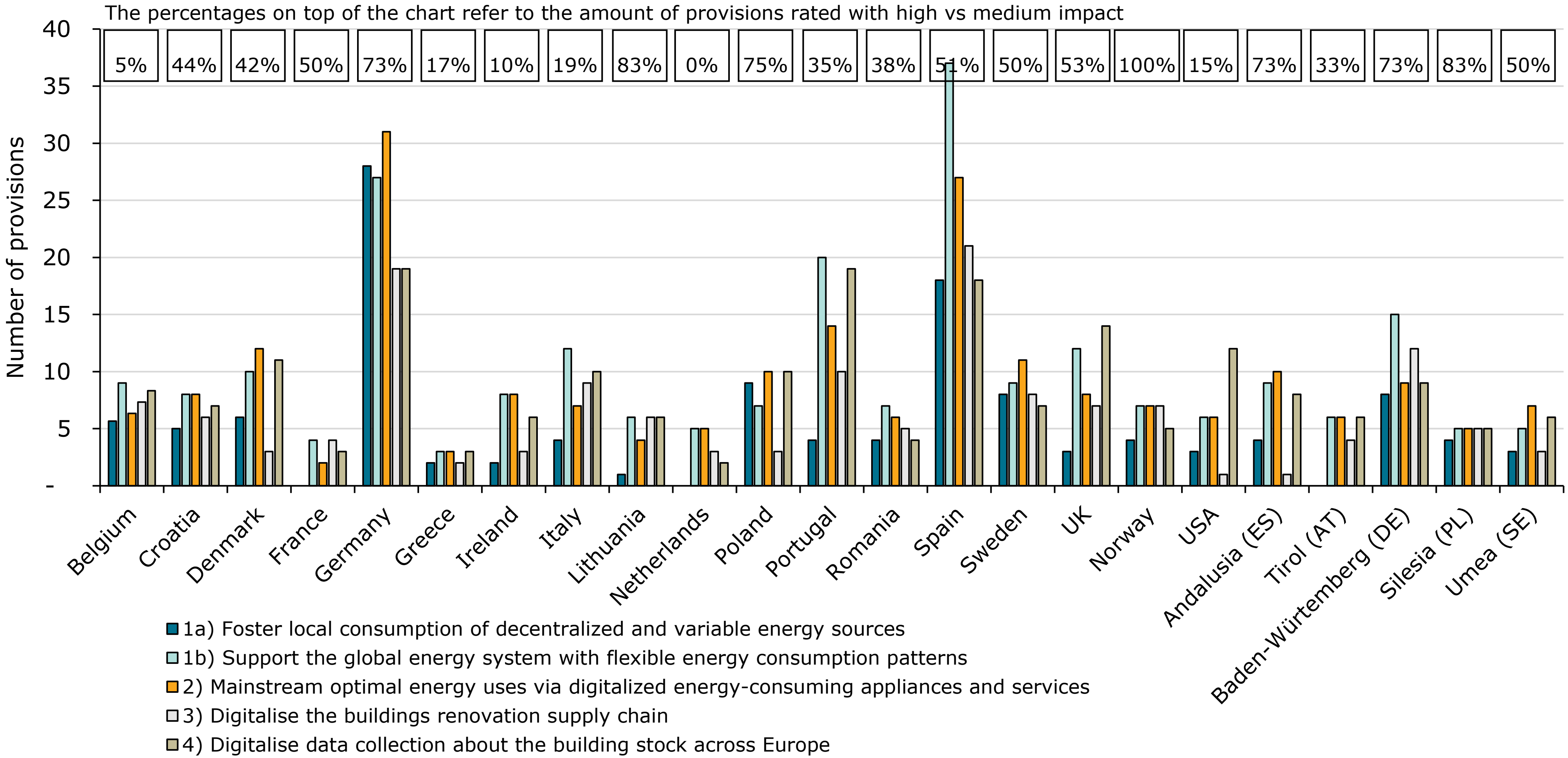

Figure 2 – Number of provisions covering the key challenges of digital technology per country

(The impact of the provisions is scored from 1 to 3, and only provisions scoring 2 and 3 are counted, giving half the weight to score 2 vs the maximum score 3)

3.4 Effectiveness of the policy landscape to address key challenges

This section presents an assessment of the overall policy landscape that a previous country screening identified as relevant for the covered countries and regions. The assessment takes into account the diversity of instruments (regulation, pricing, support, information etc.), whether there are particularly interesting and innovative instruments, and whether the instruments identified together seem to be adequate to address the given challenges. The overview tables are followed by a discussion of policy instruments.

In this context, the classification in Tables 1 and 2 should be interpreted as follows:

	Good policy landscape with at least one innovative instrument targeting district approach
	Adequate policy landscape with instruments that could in the future better integrate district approach in the building renovation policies
	Inadequate policy landscape, with no instruments identified in relation to the given challenges
	Not conclusive

Table 1 – Legislative policies

	Digital technology – legislative policies				
	KEY CHALLENGES				
	1a) Flexibility : Foster local consumption of decentralised and variable energy sources	1b) Flexibility : Support the global energy system with flexible energy consumption patterns	2) Mainstream optimal energy uses via digitalised energy-consuming appliances and services	3) Digitalise the buildings renovation supply chain	4) Digitalise data collection about the building stock across Europe
Belgium*					
Croatia					
Denmark					
France					
Germany					
Greece					
Ireland					
Italy					
Lithuania					
Netherlands					
Poland					
Portugal					
Romania					
Spain					
Sweden					
UK					
Norway					
USA					
Andalusia					
Tirol					
BW					
Silesia					

Umea					

Table 2 – Non-legislative policies.

	Digital technology – non-legislative policies				
	KEY CHALLENGES				
	1a) Flexibility : Foster local consumption of decentralised and variable energy sources	1b) Flexibility : Support the global energy system with flexible energy consumption patterns	2) Mainstream optimal energy uses via digitalised energy-consuming appliances and services	3) Digitalise the buildings renovation supply chain	4) Digitalise data collection about the building stock across Europe
Belgium					
Croatia					
Denmark					
France					
Germany					
Greece					
Ireland					
Italy					
Lithuania					
Netherlands					
Poland					
Portugal					
Romania					
Spain					
Sweden					
UK					
Norway					
USA					
Andalusia					
Tirol					
BW					
Silesia					
Umea					

1a) Flexibility: Foster local consumption of decentralised and variable energy sources

Apart from Spain and Germany, and to some extent Poland and Portugal, this key challenge is tackled to only a limited extent across Europe. These regions provide some interesting examples of legal instruments supporting more appropriate local consumption. In Spain, the national energy and climate plan (NECP) includes Measure 1.3 focused on the development of self-consumption of renewables and distributed generation through various measures such as increased financing, third-party energy services, and boosting self-consumption in vulnerable sectors. Portugal's NECP also includes measures to promote distributed production and self-consumption of energy, for example by promoting the creation and development of energy communities. In Germany, the Law on the Digitization of the Energy Turnaround (GDEW) is a German federal law on the equipment and operation of intelligent metering systems ("smart meters") in connection with energy system transformation; it includes specific elements defining protection profiles and technical guidelines for intelligent measuring systems to ensure data protection, data security and interoperability. It also contains detailed regulations on who may access what data and when.

1b) Flexibility: Support the global energy system with flexible energy consumption patterns

This area is more extensively covered across European countries, although in most cases there is still ample room for additional policy instruments. Some interesting examples include Italy, where an "eco-bonus" was introduced in 2016 for home automation with remote control of heating, hot water production and air conditioning systems of housing units. In Lithuania an amendment to the Law on Electricity enables the emergence of new services with independent aggregators of electricity demand to improve the flexibility and management of the electricity system. This is important when planning new electricity generation and consumption facilities in renovated buildings. Another example is the Royal decree in Spain which regulates self-consumption of electric energy, clarifying administrative, technical and economic conditions for self-consumption (e.g. what is the definition of a nearby facility qualifying as local consumption?), which allows local consumption to be extended and made more flexible. Portugal also included Measure 3.3 in its NECP to promote the acquisition and renewal of heat and cold production systems from renewable energy sources, where digitalisation allows more flexible exploitation of these systems to support a more efficient energy system.

2) Mainstream optimal energy uses via digitalized energy-consuming appliances and services

Most countries have at least one provision in place, and there are promising examples. Portugal has a new smart grid regulation which allows electricity bills to be calculated using real data, without any estimates, improving energy management. Poland has started the implementation and support of national intelligent specialisations, which makes smart technologies an economic priority for research, development and innovation. Also connected to research and innovation, new federal funding in Germany for the pilot programme "saving meters" supports innovative digital solutions with funding of up to €2 million. The aim is to test various technologies with different user groups and bring them to market maturity. Also, the energy action plan in Andalusia includes elements to increase the use and improve the management of renewable energy thanks to innovative energy storage systems and the use of information and communication technologies.

3) Digitalise the buildings renovation supply chain

At least two countries provide a number of adequate policy examples addressing the challenge at hand (Germany and Spain) although others also have interesting initiatives. Typically the digitalisation of the planning phase of the buildings industry is making strong progress in Germany, where a special qualification programme was put in place by the chamber of architects and engineers of Baden-Württemberg to increase the amount of qualified staff. Lithuania aims to digitise all construction management processes in one common information system through its Programme of the Government of the Republic of Lithuania (2016 Nr. XIII-82) but details are lacking. Some other countries also have non-legislative provisions, but in general provisions are lacking. Interesting examples include Energiesprong in the Netherlands, where the whole buildings renovation market is set up to encourage large volumes of renovation, which drives innovation and industrialisation. This ultimately relies on BIM for scaling and cost reductions, as does PLANBIM 2022 in France (itself inspired by the UK example) to push innovation through the buildings market (both new and renovations). PLANBIM 2022 aims to provide professionals with concrete methods and tools, capacity building and sharing best practices to massively upscale digitalisation.

4) Digitalise data collection about the building stock across Europe

Digitalised data collection is one of the stronger dimensions with most countries having some provisions, both legislative and non-legislative. However, most still remain far behind the better practices of Portugal or Spain. Portugal has had an energy observatory in place since 2017 which provides a database with all legislation, action plans, programmes and other instruments that configure energy policies. In Spain the 2030 Navarre Energy Plan is deploying energy consumption metering, creating a centralised inventory of consumption centres using the ICEGONA software, centralising procurement of energy supplies, and selecting and prioritising investments in energy service procurement, with costs linked to savings.

Several countries are now putting in place a digital logbook for buildings – a repository for all relevant building data, allowing the information to be dynamically recorded and accessed. Examples include the Belgian Woningpas in Flanders, which gathers relevant information about buildings in a digital passport, and the French carnet numérique du logement, which from 2022 will require all energy efficiency-related information on buildings renovation to be gathered electronically. Several private logbooks have also appeared, with different purposes:

- The German Eigenheim Manager and Swedish MinVilla offer building owners the possibility to store information in a digital safe.
- The Dutch MADASTER and Swedish Basta Logbook log information about the materials used in the construction phase, enabling the recycling of materials and traceability of various chemicals.

The EU Commission is also looking into digital logbooks in the context of the EU Green Deal, having issued a tender on developing an EU framework for a digital buildings logbook. The project is ongoing and will be finalised by the end of 2020.

More generally, more and more is communicated in an open and transparent way about the level of energy efficiency of buildings across Europe. In the UK energy performance certificates (EPCs) are available in an online register to everyone with an estimate of the cost of energy efficiency refurbishments required. In the same way, the Brussels region has an online database where everyone can access existing EPCs; another example would be Denmark. Looking across countries, Enerfund is trying to convert open-source databases across Europe into geocoded information to rate and score deep renovation opportunities, drawing on parameters such as EPCs, number of certified installers, governmental schemes etc. These are all initiatives that should be assessed and streamlined across Europe.

Blockchain technology is currently being tested in pilots, some of which are already used in real business cases. They help provide data that complies with strong data protection rules. An example is the Energy Card, where blockchain technology enables the visualisation of measured energy consumption data on a district level, indicating best- or worst-performing districts while protecting individual buildings data. The most prominent example for blockchain use is peer-to-peer energy trading of decentrally produced electricity (see. e.g. pebbles). This can help unlock the flexibility potential of electrified heat through local energy communities and creates synergies between heating and cooling production, improving the cost-efficiency of renewable heat by better aligning (aggregated) demand and production. Studies highlight how blockchain technology could be used for asset management as well as process optimisation throughout the building's lifecycle. Examples could include business models that aim to build demand through project aggregation, as well as process optimisation and automation in a complex and fragmented value chain. The technology allows data aggregation to better manage processes, thereby reducing investment risks, without the need to manage data protection of scattered data (see e.g. dena, BDEW).

3.5 Highlighting good practice examples

Based on the results of the previous research as well as on expert knowledge, this section portrays selected good practice examples. Each example fulfils one or several of the following selection criteria: innovation (new mechanism, triggering innovation, scaling up innovation), impact (on EU objectives, energy savings, CO_2 emission reductions, potential renovation impact), ease of implementation (including transferability, scalability, transaction and administrative costs, budget (in-)dependency, compatibility with existing legislative/policy framework) and coverage of diverse jurisdiction and climatic zones.

Country	Policy	Brief description	Source
Denmark	Energy agreement with a focus on renewable energy, energy efficiency improvements, research and energy regulation	The government has an "Energy agreement" to further build Denmark's international positions of strength with a focus on renewable energy, energy efficiency improvements, research and energy regulation. This agreement is very comprehensive and touches on a lot of issues, including "A smart and flexible energy system". Initiatives in focus include testing regulatory free zones and improved use of data and digitisation in the utility sectors. Cross-energy flexibility is particularly important and such initiatives must be replicated.	Description by the Ministry of Foreign Affairs for investors Full agreement https://kefm.dk/ministeriet/aftaler-og-politiske-udspil/energiaftalen/
Spain	Framework for the develop-ment of renewable thermal energies	Spain's framework for the development of renewable thermal energies aims to increase renewable energy sources and displace fossil fuels, expand technologies for which implementation is limited, and support the participation of new actors and innovation. It leverages two main mechanisms: reviewing and increasing energy efficiency and renewable energy requirements in the Technical Building Code for all new buildings and refurbishments, and providing aid programmes (loans and subsidies).	English version Spanish version
Germany	Law to **support grid flexibility**	The Law on the Digitization of the Energy Turnaround (GDEW) is a German federal law on the equipment and operation of intelligent metering systems ("smart meters") to support energy system transformation. In addition to amending two other federal laws and 10 directives, the Act on the Digitisation of the Energy Sector Transformation contains the new Act on Metering Point Operation and Data Communication in Intelligent Energy Networks (Metering Point Operation Act - MsbG).	Legal text https://www.bmwi.de/Redaktion/DE/Downloads/Gesetz/gesetz-zur-digitalisierung-der-energiewende.pdf?__blob=publicationFile&v=4

Germany	Optimise **energy use through automation and self-regulation**	**This policy** supports optimal **energy use through automation and self-regulation.** The aim of the federal funding for the pilot programme for energy-saving meters is to make the trend towards digitalisation also useful for energy efficiency. To this end, companies that help their end customers to save one or more of the energy sources electricity, oil, gas, biomass, heating, cooling or primary energy by means of innovative digital solutions will receive funding of up to €2 million. The aim is to test various technologies with different user groups and bring them to market maturity.	Legal text https://www.bmwi.de/Redaktion/DE/Downloads/Gesetz/gesetz-zur-digitalisierung-der-energiewende.pdf?__blob=publicationFile&v=4
Spain (Navarra)	2030 Energy plan	On the key aspect of improving, standardising **and strengthening data collection about the building stock across Europe**, the region of **Navarra in Spain** has devised a 2030 energy plan. Measures include encouraging hiring energy service companies in sectors with the greatest potential (both public and private) to develop procurement procedures and contract models and set up a support framework for possible financing; energy consumption metering; creating a centralised inventory of consumption centres using the ICEGONA software; centralised procurement of energy supplies; and the selection and prioritisation of investments in energy service procurement, with costs linked to savings.	Text in Spanish
Germany	Mainstream and establish building information modelling (BIM)	Many countries show advancements on the digitalisation **of the buildings renovation supply chain to** optimise **processes and save costs and energy**. As one example, the Ministry of Transport and Infrastructure plans to establish and mainstream BIM. After a first preparatory phase with large funds, in the second stage (2017-2020) four pilot projects are to be significantly expanded so that experience can be gathered across all design and construction phases. In the third stage (from 2020), BIM is to be regularly applied for new projects that the Ministry is responsible for.	Text in German https://www.bmvi.de/SharedDocs/DE/Publikationen/DG/stufenplan-digitales-bauen.pdf?__blob=publicationFile
Spain	Updating criteria for energy performance certification	Spain has also updated its criteria for recognised documents for energy performance certification to increase the chances of including advanced solutions to improve the energy performance of buildings and promote technological innovation in the sector.	

		Since 2016, the recognised programmes for energy performance certification have to generate a digital file in XML format, containing all the data from the certificate, which must be provided at the time of registering.	
Spain		Spain has put in place a large plan for energy saving and efficiency, promotion of renewable energy and self-consumption in public-sector buildings, infrastructure and equipment administered by the Valencian regional government. It helps with the following issues: • Creating a building energy management platform • Promoting energy audits and energy certificates for public buildings • Creating an energy management plan for public buildings, infrastructure and equipment • Investing in energy saving and efficiency, as well as in renewable energy • Promoting electricity production for self-consumption • Including energy efficiency criteria in the system of procurement and management procedures • Creating mobility plans and implementing training, awareness-raising and information programmes for users and energy management officers in public buildings.	Text in English Text in Spanish https://ec.europa.eu/energy/sites/ener/files/documents/es_neeap_2017_es.pdf

3.6 Concluding assessment

The key identified challenges of the digital technology policy area are tackled to a varying degree across regions, but mostly to a disappointing degree as reflected in the two main tables of this factsheet. Overall, Germany and Spain have developed a large set of policies that touch on the five key aspects of digitalisation, and some others have started well on certain dimensions (Portugal, the UK), but most other countries have limited ambitions, especially with regard to fostering local consumption of energy and digitising the buildings renovation supply chain. Many countries tend to have non-legislative initiatives in place but lack a sufficiently strong supporting legal environment and will need to make significant progress.

Looking across the provisions in place, we see that there are:

- Comprehensive strategies: these typically cover a much wider range of policies than just digitalisation but include some of the elements required to support it. Typical examples include the German national strategies (e.g. Energiewende, Energy Efficiency strategy for buildings). They don't seem to be coming out as strongly in other countries.
- More specific programmes on digital issues**:** a whole series of policies have been implemented across Europe, from the Smart Meters Act of 2018 in the UK, to the agreement on a smart and flexible energy system in Denmark, or the Royal Decree regulating self-consumption of electric energy in Spain. Many countries are failing to cover sufficiently the various key aspects with these specific instruments.

Assessment of impact per type of policy instrument

The country analysis allows us to draw general trends regarding the various types of policy instruments and the impact they have on key challenges.

The results of the country analyses contain very few examples of private financing instruments. When they are mentioned, they mostly support realising the flexibility potential from dispersed consumption/production and optimising energy use through digitisation (key challenges 1 and 2).

Public financing initiatives, such as grant mechanisms, are more common. They also mainly address key challenges 1 and 2. For example, in Spain, the low-carbon economy network REBECA subsidises, among other things, the transition to low-energy consumption in public and residential building projects, notably through smart energy management.

Not surprisingly, standardisation initiatives were found to address mainly key challenges 3 and 4, i.e. the digitisation of the building renovation supply chain and the building stock data collection respectively. A good example is the national implementation in Germany of the buildingSMART International Industry Foundation Classes. The impact of these initiatives is usually judged as high.

The second most represented category is legislative instruments, which are found across all key challenges. In the country analysis, the impact of such instruments was found to be high as often as medium. Those that have a high impact often relate to smart metering and real-time tariffing. Countries with such 'high impact' pieces of legislation include Denmark, Germany, Spain, Greece, Portugal and the UK.

As the most represented category, public and private initiatives cover all key challenges in the most balanced way. These are also the most diverse type of instrument, with initiatives such as events, dissemination of information and pilot projects. As the impact of these initiatives varies, we have not attempted to assess their energy saving and greenhouse gas emissions reduction potential. Among such initiatives ranked with high impact on the key challenges, we can point out pilot projects carried out by municipalities, Alba Iula (Smart City Initiative) and Umea (Energy Project).

Ease of implementation per type of policy instrument

Financing instruments have to be considered cautiously in light of the EU legislation on state aid and competition. This has been seen in the recent past, notably for state subsidies to residential PV installation.

In terms of standardisation, even though some standards cover international areas, habits and inertia in national buildings institutions might hamper harmonisation between countries of digital technology standards to facilitate the transition towards low-energy buildings. However, standardisation of e.g. interfaces is highly relevant in this area to allow for integrated building systems, monitoring, data collection and renovation planning, especially in the case of project aggregation. It can thus be considered as one of the main fields of action the EU could support. One such initiative is the smart readiness indicator developed by the European Commission in order to foster smarter buildings.

Legislative instruments, as well as private and public initiatives, can be replicated from one country to another, but successful adaptation of good practices depends on the political regime at national level and local specificities.

District approach – Factsheet

Authors: Quentin Jossen, Louis Louvet

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4.1 Introduction

This factsheet provides an overview of how different policy instruments and selected private initiatives can help to achieve European objectives and effectively address key EU challenges in the strategic area of **district approach**. The findings draw upon a policy screening for 15 EU Member States, 3 non-EU countries and 5 European regions covering broadly the climatic zones of the EU. In addition, the factsheet draws on additional information provided by external experts as well as on the long-standing expertise of the authors, meaning policy examples going beyond the researched country and region cases are occasionally added. The concluding assessment draws on the findings and detailed analysis of the good practice cases as well as on the in-house expertise of the partners.

4.2 District approach

Building renovations can be planned and organised by adopting a comprehensive approach that aims to renovate not only single building units, but rather a district or a neighbourhood at the same time. Renovations at the district level can lead to potentially significant cost reductions through economies of scale, industrialisation of solutions and smart logistics; they can also increase the attractiveness of investments thanks to project aggregation and distributed risk portfolios. Moreover, the approach fosters synergies between energy efficiency and other needed transformations in the district, including joint consideration with the development of local renewable energy sources or urban development strategies. Given all these aspects, district approaches have the potential to lead to optimal solutions at macro level, combining energy efficiency with a maximisation of its multiple benefits and ensuring consistency with the other aspects of the sustainable development of cities and territories.

District approaches will help to tackle three key challenges in the renovation of existing buildings in the EU:

1) Developing integrated approaches maximising the synergies between energy efficiency and renewable energy (integrated energy efficiency (EE)/renewable energy sources (RES) approaches): reaching decarbonised buildings by 2050 requires integrated approaches planning renewables and energy efficiency measures together. Optimal renewable and energy efficiency solutions are more likely to be found when designed on a district level, considering the constraints and the potential of the specific location in order to minimise total costs and maximise benefits.

2) Streamlining and aggregating renovation solutions and processes (streamlining and aggregation): residential districts typically have common building characteristics, requiring similar renovation solutions, but very often renovation opportunities are not aggregated at the district level. The key challenge is to identify and capture the standardisation and aggregation potentials of renovation solutions and processes considered at the district level.

3) Developing comprehensive (sub)urban strategies combining energy and carbon efficiency of the building stock with sustainable solutions for growth and improvement of citizens' wellbeing (Comprehensive (sub)urban strategies): growing demographic and evolving living and mobility patterns might push towards an unsustainable urban exodus. The key challenge is to embed building energy renovation into larger land-use planning strategies. Planning renovation and infill strategies at the district level maximise benefits and increase positive synergies.

Provisions related to the above challenges were collected for 18 countries and 5 regions, mainly in the EU. The present analysis aims to highlight interesting initiatives from these countries or regions with regards to district approaches to renovation and, more broadly, to provide an overview of what is happening in the EU on this topic. To this end, the paper summarises and discuss how those countries and regions consider district approaches in their building renovation policies. The paper starts with a general overview of collected policies in Section 3. Then, specific insights for each of the three key EU challenges are provided in Section 4 and best practice examples are highlighted in Section 5. Lessons learned to further foster the development of district approaches to buildings renovations are provided in the conclusions drawn in Section 6.

4.3 Provisions to address key challenges

This section gives an overview of the policies considered to be most successful at tackling key challenges in the area of district approaches. To operationalise the challenges and allow for quantitative estimations on selected aspects, the country screening looked for provisions that could maximise synergies between energy efficiency and renewable energy sources, streamline renovation solutions and support sustainable urban growth.

The figure provides an overview of the policy screening. Since countries vary in size, the number of provisions does not necessarily reflect the effectiveness of the policy mix. While the number of provisions found may give an indication of the breadth and diversity of approaches, it should not be taken as the sole indicator for how effective the provisions are for tackling key challenges. One well-designed policy instruments may be more effective than a multitude of less adequate instruments. Therefore, an additional qualitative discussion as well as insights from the good practice analysis are provided in the remaining parts of the paper.

District approaches to efficiently unlock the renovation of the building stock are relatively new in political agendas of all kinds. Only a few specific policies consider building renovation at the district level (we found less than 10 provisions for most of the considered countries and regions and very few strongly connected to district-scale renovation of existing buildings). Pioneering countries in this regard are usually at an experimentation stage (they are conducting initiatives in order to assess the requirements and benefits of such approaches) and most initiatives are recent (less than five years old, and rarely a continuation of previous initiatives/programmes).

The scale of implementation can be very local. Since it is a new approach, most measures have not yet reached the national level (e.g. national legislation or major plans and programmes like the national energy and climate plan (NECP), long-term renovation strategy (LTRS), etc.). The overview does not pretend to be exhaustive given potentially weak international communications of local initiatives. We therefore carried out an additional review focused on local initiatives to complement the initial review of policies led at national and regional levels. Furthermore, several pioneering international projects provide recent learnings on district approaches, which are reflected in the discussion as well as in more detail in section 4.2. They are, however, not included in the assessment figures below.

An overview of the number of provisions addressing each key challenge is provided in Figure 1. The following paragraphs discuss the results in terms of key challenge coverage and geographies. A total of 80 provisions were found dealing with district-scale actions providing a favourable policy landscape to further develop district approaches to renovation (Figure 1, top). Of these, we assess that only 22 provisions have the potential to impact the challenges discussed above (Figure 1, bottom). In terms of numbers, a single overarching provision can certainly have more impact than 10 smaller provisions. However, with the exception of schemes found in the Netherlands and discussed below, no overarching provisions related to district approaches to renovation were found in the country review and the additional analysis.

Many provisions targeting district-scale actions relate to district heating/cooling and urban planning. These are mature policies in several Member States, well reflected at the national or regional level, which explains the higher amount of provisions relating to the corresponding key challenges (64 provisions for integrated EE/RES approaches and 41 provisions for comprehensive (sub)urban strategies). However, there is no systematic strong connection with energy renovation of existing buildings. Thirty provisions were found in connection with the streamlining and aggregation of renovation. A series of them focus on streamlining renovation processes and structuring scalable solutions without specifically addressing district approaches at their current development stage.

District approach provisions with potentially strong impact on the renovation of the envelope and heating systems of the existing building stock mainly relate to the streamlining and aggregation of renovation works (15 provisions). Explicit connections with building renovation were found for only a few provisions relating to integrated EE/RES approaches and comprehensive (sub)urban strategies (six and five provisions respectively).

In terms of geographies, provisions strongly connected to building energy renovation and the given challenges were found in Flanders, Denmark and the Netherlands (with three provisions each) and Brussels, Ireland and Tirol (two provisions each), and finally Wallonia, Germany, Lithuania, Poland Romania, Spain, Sweden and the USA (one provision each).

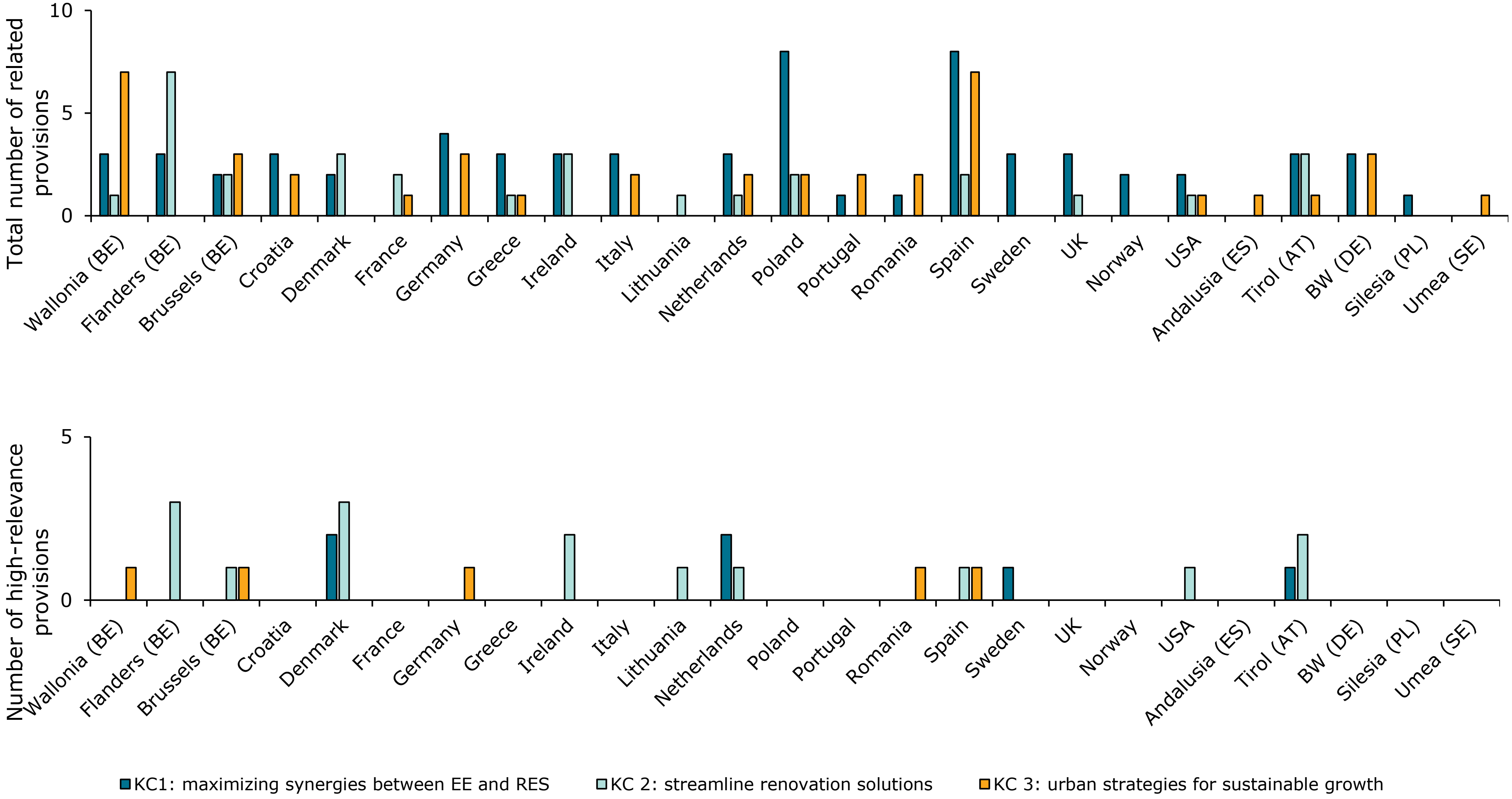

Figure 3 – Number of provisions by country and by key challenge relating to district-scale approaches (top) and subset of these with explicit connections to the renovation of the existing building stock and the given challenges (bottom)

4.4 Effectiveness of the policy landscape to address key challenges - overview and description

This section presents an assessment of the overall policy landscape that a previous country screening identified as relevant for the covered countries and regions. The assessment takes into account the diversity of instruments (regulation, pricing, support, information etc.), whether there are particularly interesting and innovative instruments, and whether the instruments identified together seem to be adequate to address the given challenges. The overview tables are followed by a discussion of policy instruments.

In this context, the classification in Tables 1 and 2 should be interpreted as follows:

(green)	**Good policy landscape** with at least one innovative instrument targeting a district approach
(yellow)	**Adequate policy landscape** with instruments that could in the future better integrate a district approach in the building renovation policies
(red)	**Inadequate policy landscape**, with no instruments identified in relation to the given challenges
(grey)	**Not conclusive**

Tables 1 and 2 lead to the following observations, further discussed by key challenge in the next sub-sections:

- With the exception of Flanders and Ireland, no country or region has both legislative and non-legislative provisions strongly connected to district approaches to buildings renovation in place. Regarding provisions that target district-scale actions in a broader sense, the combination of legislative and non-legislative provision is found in 12 of the reviewed countries for the first key challenge, and three countries/regions for each of the two other key challenges.
- A good policy landscape is found in Spain, with high-relevance legislative provisions for two key challenges. The same goes for non-legislative provisions in Brussels, Denmark, the Netherlands and Tirol.

There is not always a clear distinction between legislative and non-legislative provisions. Therefore, the two tables are jointly discussed below for each of the three key challenges.

Table 1 – Legislative policies

	District approach – legislative policies		
	KEY CHALLENGES		
	Develop integrated approaches maximising the synergies between EE/RES	Streamlining and aggregating renovation solutions and processes	Developing comprehensive (sub)urban strategies combining energy and carbon efficiency
Wallonia			
Flanders			
Brussels region			
Croatia			
Denmark			
France			
Germany			
Greece			
Ireland			
Italy			
Lithuania			
Netherlands			
Poland			
Portugal			
Romania			
Spain			
Sweden			
UK			
Norway			
USA			
Andalusia			
Tirol			
BW			
Silesia			
Umea			

Table 2 – Non-legislative policies.

	District approach – non-legislative policies		
	KEY CHALLENGES		
	Develop integrated approaches maximising the synergies between EE/RES	Streamlining and aggregating renovation solutions and processes	Developing comprehensive (sub)urban strategies combining energy and carbon efficiency
Wallonia			
Flanders			
Brussels region			
Croatia			

Denmark			
France			
Germany			
Greece			
Ireland			
Italy			
Lithuania			
Netherlands			
Poland			
Portugal			
Romania			
Spain			
Sweden			
UK			
Norway			
USA			
Andalusia			
Tirol			
BW			
Silesia			
Umea			

1) Developing integrated approaches maximising the synergies between energy efficiency and renewable energy

Two provisions were found fully tackling the integration of energy efficiency and RES at the district scale. The first is found in the Netherlands with its Heat Transition Vision, where participating municipalities commit to develop by 2021 a vision on how each of their districts could be made natural gas-free, and the related national programme aimed at supporting districts/municipalities to become natural gas-free through deep renovations and integration of renewable heating at district level. The second provision is the districtPH tool – developed by the Passive House Institute in the Austrian state of Tirol – designed for the evaluation of energy saving and RES heat potentials at the district level. Furthermore, the Smart Cities Information System platform provides general guidelines to approach district renovation and heating and balancing energy efficiency and the integration of renewables, for example in its solution booklets for district heating and cooling, building envelop retrofit, and heat pump driven district heating systems.

A series of other provisions relate to the integration of EE and RES approaches without an explicit connection to the renovation of the existing building stock. These were mainly three types:

- **Deployment and decarbonisation of heating/cooling districts**. Some countries are conducting studies (e.g. measure 4.7 of the Spanish NECP: Promotion of high-efficiency cogeneration and district heating and cooling that includes the development of a tool to identify the share of the heating demand that could be met with efficient district heating) while others have already brought requirements into law (e.g. the Swedish district heating law) or standards (e.g. the Italian district energy system standard). A series of other provisions aim to increase the share of RES in district heating.
- **RES heat potential mapping**. Many regions are conducting mapping of their district in order to assess the geothermal/solar/heat capacity/etc. potential: the BruGeoTherMap in Brussels aims to valorise the geothermal potential of the

Brussels region, Flanders is developing local heat zoning plans to adapt the heat supply to local characteristics (NECP p.88), and Croatia is mapping its energy system with a comprehensive database of geo-referenced information on the consumption of energy and energy sources, buildings and infrastructure (4th NEEAP, measure HC.1, p.110).

- **Energy communities**. These provisions consist of micro-grid initiatives aiming to balance local production and consumption of energy. Examples include Brussels with a collective self-consumption pilot project with solar production from schools shared with the neighbourhood outside of school hours; Italy with single and collective self-consumption systems where electricity consumers can join together to become self-consumers of renewable energy acting collectively, thus creating a renewable energy community (NECP p.141 related to law decree No 162 of 30 December 2019); and similar provisions in Portugal (NECP p.34) and Spain (NECP measure 1.11, p.75). Other interesting initiatives are the better energy communities grant in Ireland and the Portland Clean Energy Community Benefits in the USA.

Although connections with building renovation are not yet explicit in these provisions, they are useful enabling initiatives to structure integrated EE/RES approaches to renovation.

2) Streamlining and aggregating renovation solutions and processes

Most provisions related to the streamlining and aggregation of renovations explicitly foster building renovation at the district level and provide learnings from pilot projects**.** Cities and districts are, in fact, a big driver for the aggregation of renovation demand and larger numbers of dwellings in projects directly affect associated risks and can drive economies of scale. Communities driving the development of district approaches, like Smart Cities Networks, thereby help drive (deep) building renovation".The district refurbishment in Aalborg, Denmark, tackles the renovation of around 950 dwellings (representing 97,000 m² of heated floor area) and should provide results in the course of 2020. The demonstration project for collective renovation in Flanders aims to trigger the refurbishment of 875 houses in two cities (Antwerp and Mechelen) towards ambitious energy performance levels and runs until 2024. The ICCARus project (Improving housing Conditions for Captive Residents in Ghent) aims to renovate 100 dwellings from energy precarious households and to build a replicable and sustainable system through analysis of the social return on investment. The project expects numerous co-benefits for applicants, including progress on health, social networks, socio-economic position, etc. Some pilot projects have already been upscaled due to their success, as is the case for the collective renovation in Ghent.

Additional pilot projects testing district-level renovation approaches are also found in the reviewed international projects (see section 4.2). Under the Sinfonia project, 37,000 m² of social housing in Bolzano (Italy) and 66,000 m² in Innsbruck (Austria) were refurbished; a total of 226,000 m² across six European cities were retrofitted within EU-GUGLE; and City-zen and R2CITIES projects have respectively renovated 76,000 m² and 57,000 m². Moreover, the EU Smart Cities Information System (SCIS) provides information on several other projects where single or multiple districts will be renovated to become energy efficient or energy positive districts all over Europe. This is illustrated by projects like E2REBUILD (cost-effective and advanced energy efficiency retrofit strategy development), FLEXYNETS (new generation intelligent district heating and cooling), or PITAGORAS (smart thermal grids).

Despite the generally local character of district approaches, some provisions are structured at the national or regional level**.** The Renovation accelerator in the Netherlands is a national programme to incentivise large-scale energy renovations that runs for the period 2019-2023, with a project threshold at 150 buildings units, thereby also promoting the Stroomversnelling/Energiesprong initiative. The Neighbourhood Grant in Flanders is a bonus for project supervisors who collectively supervise a number of homes (at least 10) in order to make them energy efficient. The Community Areas Housing Efficiency Strand 2020 in Ireland is a grant scheme supporting large retrofitting and encouraging scalability. It also includes a one-stop-shop approach. A special regional support programme supports serial renovation in Baden-Württemberg.

Industrialised prefabricated renovation solutions are developed within some initiatives. The prefabricated renovation solution in Hyldespjaeldet (Denmark) (Green solar cities p.4.127-4.130 and annex 2 & 3 from TUE) consists of prefabricated modules for external insulation of flat roofs and walls. The roof module combines insulation with solar photovoltaics, solar thermal and water recuperation. Within EURECA in Flanders, researchers are developing a circular façade system for fast and scalable renovation solutions.

3) Developing comprehensive (sub)urban strategies combining energy and carbon efficiency of the building stock with sustainable solutions for growth and improvement of citizens' wellbeing

Some interesting provisions structure energy efficiency and renovation plans at higher scales than individual buildings. The Vulnerability and Residential Building Atlas in Spain is a web platform supporting the assessment of local renovation needs to promote municipal urban renovation, regeneration and renewal strategies. In Romania, local authorities with more than 5,000 inhabitants must draw up an EE improvement programme, and those with more than 20,000 inhabitants must appoint an energy manager. In Wallonia, the territorial development plan measure AM.1 aims to reuse "well" located buildings and combat urban sprawl thus providing a sustainable solution for growth. In the same fashion, in Germany a grant for energetic urban redevelopment finances neighbourhood concepts and redevelopment managers.

Provisions with less explicit links with the energy renovation of existing buildings were mainly of three types:

- **Infill strategies and rehabilitation of buildings**: For example, Spain has a housing plan for 2018-2021 that aims to promote urban rehabilitation and regeneration, and projects can be funded through the JESSICA FIDAE Fund. In the Netherlands, Crowdbuilding is an online platform to facilitate the reuse of vacant buildings through collective buying. In Portugal, the Financial Instrument for Urban Rehabilitation and Revitalization aims for 23% of business volume in the construction sector to be allocated to urban rehabilitation. A provision is structured in Wallonia to ensure smart use of lands and well-located buildings via fiscal and urban planning instruments
- **Sustainable urban energy efficiency plans**: the POLLEC campaigns help local authorities in Wallonia to implement an energy-climate policy and to develop and implement municipal action plans for sustainable energy. The National Operation Programme for metropolitan cities 2014-2020 in Italy is a programme dedicated to sustainable urban development.

- **Sustainable urban planning projects encompassing energy efficiency, RES and health benefits (new built):** In the Baden-Würtenberg region, Riselfeld, the largest district project, covers an area of some 70 hectares, and now provides 3,700 homes for 10,500 people. All houses have been built as low-energy buildings. Photovoltaics and solar thermal systems harness the energy from the sun in many homes, and a systematic water supply plan and consideration of climatic aspects attest to the fundamentally forward-looking approach of this very new district. A similar approach exist for the Vauban district (for about 5,700 people). The CORDEES project in Paris is creating a new 54-hectare energy eco-district combining energy efficiency, 85% of self-supplied energy and energy managed through the Urban Sustainability Trustee Facilitator. A similar project is being developed in Berlin Neulichterfelde. These district-scale pilot initiatives relate to new builds, but certainly bring learnings for district approaches to renovation of existing buildings.

4.5 Highlighting good practice examples

Based on the results of the previous research as well as on expert knowledge, this section portrays selected good practice examples. Each example fulfils one or several of the following selection criteria: innovation (new mechanism, triggering innovation, scaling up innovation), impact (on EU objectives, energy savings, CO_2 emission reduction, potential renovation impact), ease of implementation (including transferability, scalability, transaction and administrative costs, budget (in-)dependency, compatibility to existing legislative/ policy framework) and coverage of diverse jurisdiction and climatic zones.

Best practice examples provided in Table 3 were selected to highlight inspiring provisions explicitly relating to the given key challenges as well as to key success factors, namely methodologies and tools. Priority in the selection was given to ongoing projects or policies.

Table 3 – Selection of best-practice policies

Country	Policy	Brief description	Source
Initiatives providing new methods and tools			
Sweden	Integration of energy and climate aspects in planning work in Ovanakers municipality	• Development of a digital tool based on GIS which uses a multi-criteria analysis valuation method to integrate energy efficiency and climate aspects in municipal planning. • The project is interesting for other municipalities that have access to GIS software.	https://www.ovanaker.se/boendeochmiljo/samhallsplaneringochplaner/projektinomsamhallsplanering.4404.html
Tirol (DE)	Tool for energy savings potential and related best practices	• districtPH is a tool used to create energy balances for neighbourhoods, taking into account grids for electricity and heat, renewable energies, electromobility and public consumers. • This tool has been developed with the Sinfonia project and is used by the Passive House Institute, which was a stakeholder of the project. • The tool has been used to renovate multiple districts in Innsbruck and results from those projects can serve as best practice guidance for future refurbishment.	districtPH Passive House Institute booklet
Flanders (BE)	Local climate roundtables for district level renovation	• The involvement of stakeholders from the start is of prime importance in conducting any type of refurbishment project. • Local roundtables bring all stakeholders and interested parties around the table locally: governments, individuals, associations, businesses etc. • Developing projects of "district-level renovation", thereby including local authorities to identify the needs, citizens and businesses concerned in the neighbourhood to be renovated, local energy and housing organisations, the financial sector, local suppliers and installers of sustainable products.	NECP p.291

		• Sharing good practices with other local climate roundtables.	
Provisions developing integrated EE/RES approaches			
The Netherlands	Natural Gas-Free Districts Programme	• National programme aimed at supporting districts/municipalities to become natural gas-free through deep renovations and integration of renewable heating at district level. • Objective: to get 1.5 million buildings "natural gas-free" by 2030. • Requirement for each municipality to develop a vision on how each of its districts could be made natural gas-free. • Next step will be the development of district implementation plans to put the vision into practice. These plans will have to include the deadline by which each district will be cut off from natural gas. • First "learning" phase 2018-2021 based on two pillars: ○ A "Knowledge and Learning Centre" (accessible for all Dutch municipalities) will provide technical support and facilitate information sharing/best practices ○ Frontrunner municipalities or districts can get financial support for demonstration/implementation in "Test Beds for Natural Gas-Free Districts".	https://aardgasvrijewijken.nl/default.aspx https://ec.europa.eu/energy/sites/ener/files/documents/nl_final_necp_main_en.pdf (NECP p. 31-32)
Flanders (BE)	Local heat zoning plans	• Area-specific heat plans, including a heat zoning plan, a heat vision and measures to bring about the transition. • Rationale: the possibilities for utilisation of residual heat or production of green heat depend strongly on the local (spatial) context. It is necessary for the heat supply to be area-specific. It is therefore desirable for local authorities to draw up (or have drawn up) heat plans for their territory.	NECP p.88
Provisions aiming at streamlining and aggregating renovation			
The Netherlands	The renovation accelerator	• Objective: to bundle/aggregate the demand for renovation of similar housing types, and have the supply chain match it. Through standardisation and economies of scale, this is expected to lower costs, optimise supply chains and timing, etc. • Supports housing corporations both through subsidies (budget of €100 million over the period 2019-2023) and through technical and process assistance. • Order of magnitude: for the subsidies, the threshold for a project is at least 150 building units (with at least two housing corporations participating for at least 50 housing units each).	https://derenovatieversneller.nl NECP p.65
Denmark	"Master Plan South" project in Albertslund	The project renovated 2,200 dwellings in the municipality of Albertslund, focusing on concrete buildings. The municipality aimed to serve as Danish climate test site concerning energy-efficient renovation of concrete housing areas.	https://albertslund.dk/servicemenu/english/about-albertslund/housin

	and prefabricated renovation in Hyldespjældet	Amongst a series of subprojects, an innovative initiative in Hyldespjaeldet consisted of renovating 390 flat-roof houses with a high degree of industrial prefabrication. The prefabricated renovation solution consisted of: • A roof module combining external insulation, solar photovoltaics and solar thermal modules, and a water recuperation system (*solar prism* from Velux) • A façade external insulation module. The vision is to enable independence of households from all grid networks but electricity.	g Green solar cities p.4.127-4.130 annex 2 & 3 from TUE
Flanders (BE)	Neighbourhood Grant	• Bonus for project supervisors who collectively supervise several homes (at least 10) in order to make them energy efficient. • At least 10 houses or apartments situated in the same street or municipality. • The project supervisor provides support to citizens in realising energy-saving investments. • As a citizen, you have more certainty that the renovation work will be carried out more quickly, with lower investment costs.	https://www.energiesparen.be/burenpremie https://www.vlaanderen.be/burenpremie-voor-collectieve-renovatieprojecten
Provisions developing comprehensive (sub)urban strategies			

Wallonia (BE)	Valuing land and reusing "well-located" buildings	• Objective: to combat urban sprawl, make rational use of territories and resources and control mobility.
		• Measures include:
		  ○ Aiming for 50% new housing in urban and rural centres by 2030 and 75% by 2050.
		  ○ Modifying tax incentives and renovation premiums based on the suitability of the location.
		  ○ Identifying the areas in which intensification of housing is appropriate.
			Territorial Development Plan (2019), measure AM1, p.46

Table 4 provides an overview of EU projects also considered as best practices in the field of district approaches. They consist of research and/or pilot projects to boost knowledge and experience on district-scale renovations, shedding light on the key success factors for such approaches. They generally involve two or three pioneer cities testing the solutions as well as replication cities to test the replicability of the developed methodology and tools.

Besides national, regional and local initiatives, a series of international projects bring valuable insights on the required components to enable and foster district approaches to energy renovation of existing buildings. Some of these are included within national or regional provisions:

- Mutual trust, clear communication and stakeholder involvement is tremendously important and is necessary from the very start to ensure a smooth process. For this communication and involvement to take place in complex contexts, some projects have developed tools to clarify and smooth the overall process (e. g. NewTREND, OptEEmAL for international projects, but also at the national/regional scale the local climate roundtables in Brussels and the Renovation Accelerator in the Netherlands). Another necessary requirement for a successful initiative is a strongly supportive municipality (or public authority) that must be the leader and owner of the project. The natural-gas free district programme in the Netherlands is a good example of public authority support.
- There are three key roles to ensure successful initiatives: *activators* should understand platform-based approaches and methods to empower people; *facilitators* ease the renovation process on the entire customer journey once they are initiated; *monitoring committees* composed of local stakeholders should follow all initiatives in a district to ensure their consistency with different objectives. Amongst these, the role of facilitator is already getting attention with a number of provisions: the Neighbourhood Grant in Flanders (provides a bonus for project supervisors that supervise at least 10 homes for energy efficiency renovation); Energetic urban redevelopment in Germany (grant to support sustainable urban redevelopment at district level with special financing for the preparation of renovation managers); the Renovation Accelerator in the Netherlands (boosting large-scale energy renovations with strong focus on developing the supply chain to match the demand).
- There is a need for new operating methods and tools adapted to coherent district approaches. These tools and methods should ensure the success of projects no matter the context-specific issues that are inherent with a localised approach. Many of the international projects presented in section 4 designed and assessed different models and tools adapted to district-level renovation projects, including MODER, EU-GUGLE, OptEEmAL, Sinfonia and NewTREND. Methodologies and tools are also being developed under annex 75 from IEA EBC and should be delivered in the course of 2021. The development of tools and appropriate methodologies is also considered in a selection of national provisions: the residential building atlas in Spain (web platform that supports local assessment of renovation needs and urban renovation by developing a standard methodology); the Renovation Accelerator in the Netherlands (national programme to incentivise large-scale energy renovations, promoting standardisation of practices); the DistrictPH in Germany (tool for the evaluation of energy-saving potentials at district level); GIS-based tool for municipal planning in Sweden (to integrate energy efficiency and climate aspects).

Multiple factors hinder replication of successful initiatives:[19]

- The “we are unique” syndrome: Success and failure factors derive from both generic features of the scheme and local context specificities. It’s not just about technologies and business plans. Everything must be there at the right place at the right moment.
- Business as usual is too easy: There is a high demand for building and installation contractors, which provides no incentive for innovation. On top of this, financiers display strong risk aversion and wait for innovative markets to be fully established.
- From payback time to secondary benefits and willingness to pay: There is a need to monitor and document multiple benefits of deep renovation projects, and to communicate and build capacity at all stages within the market and the authorities.
- Regulatory bottlenecks sustained by vested interests and system inertia: The given rules need to be re-read or re-studied to bring forward possibilities that were previously ignored. Bringing multiple political responsibilities on board will be key to activate the needed modifications.

The upcoming challenge will be to overcome these barriers and foster market uptake and replication.

[19] European Commission, 2018. Why may replication (not) be happening

Table 3 – EU projects bringing valuable insights on district approaches

Project	Brief description
IEA EBC annex 75 (International Energy Agency, Energy in Buildings and Communities programme) [2017-2022]	• Title: Cost-effective Building Renovation at District Level combining Energy Efficiency and Renewables • Objectives: - To give an overview on various technology options and how challenges specifically occurring in an urban context can be overcome - To develop a methodology supporting decision-makers in the evaluation of the efficiency, impacts, cost-effectiveness and acceptance of various strategies for renovating urban districts - To illustrate the development of such strategies in selected case studies and gather related best-practice examples - To give recommendations to policymakers on how they can influence the uptake of cost-effective combinations of energy efficiency measures and renewable energy measures in building renovation at district level, and to give guidance to building owners/investors on related cost-effective renovation strategies.
MODER project [2015 - 2018]	• Title: Mobilization of innovative design tools for refurbishing of buildings at district level • Objectives: - To develop tools for design at district and neighbourhood level that enable the comparison of different RES systems - To improve non-technical stakeholders' understanding of the behaviour of complex energy systems through visualisation of alternative energy scenarios. - To improve holistic energy-system design at district level considering renewable energy systems (through optimal selection and sizing of energy conversion units as well as the energy distribution system) - To develop processes and practices that enable building owners to activate refurbishment with the help of energy management companies and engineering companies, and develop business models for engineering companies, consultants and energy managers to profitably offer these services.
Sinfonia [2014 - 2019]	• Title: Smart INitiative of cities Fully cOmmitted to iNvest In Advanced large-scale energy solutions • The SINFONIA project is a five-year initiative to deploy large-scale, integrated and scalable energy solutions in mid-sized European cities. • At the heart of the initiative is a unique cooperation between the cities of Bolzano and Innsbruck, complemented by five 'early adopter' cities (Pafos (CY), Rosenheim (DE), Seville (ES), La Rochelle (FR) and Borås (SE)) and more than 40 replication cities across the EU. • A large part of the project is therefore dedicated to the transferability and scalability of the solutions. • SINFONIA will define a limited set of district typologies and corresponding refurbishment models, enabling cities to easily assess their needs and efficiently define their long-term refurbishment strategies.
EU-GUGLE [2013 – 2019]	• Title: European cities serving as Green Urban Gate towards Leadership in sustainable Energy • Objectives: - Development and implementation of a methodology for energy diagnosis and refurbishment of buildings, including an economic viability check tool for energy efficiency measures

	- Definition and testing of a smart metering concept, based on consultations and feedback received from end users - Development of different smart promotion schemes to promote innovative integration of energy measures into buildings - Analysis report of financing energy efficiency and RES integration.
READY [2014 – 2019]	• Title: Resource Efficient cities implementing ADvanced smart citY solutions • Objective: Demonstration of a whole city approach including, among others: - Demonstration of a balanced and holistic approach towards affordable retrofitting of residential buildings and offices. - Development and demo of flexible combined grid balancing/energy storage solutions for buildings and RES systems - Development and demo of new solutions for low-temperature district heating, components and management ICT systems - Solutions for water efficiency and wastewater energy recovery.
R2 cities [2013 - 2017]	• Title: Renovation of residential urban spaces: towards nearly zero energy cities • Objective: Develop and demonstrate replicable strategies for designing, constructing and managing large-scale district renovation projects for achieving nearly zero energy cities • 3 demo sites: Genoa (IT), Kartal (TK), Valladolid (ES)
ZenN [2013 - 2017]	• Title: nearly Zero ENergy Neighbourhood • Objectives: - Demonstrate the feasibility of innovative low energy renovation processes for buildings at the neighbourhood scale - Identify, optimise and disseminate the most promising management and financial schemes to facilitate large-scale replication - Develop, improve and launch ambitious replication plans at local and regional scales.
CITyFIED [2014 – 2019]	• Title: Replicable and innovative future efficient districts and cities • Objective: A mix of demonstration, innovative technologies and sound business models towards the smart city of the future ▪ CITyFiED aimed to deliver sustainable and efficient urban districts and to provide a high quality of life to their inhabitants through optimal management of resources.
City-zen [2014 – 2019]	• City-zen was a joint project of Amsterdam, Grenoble and 28 partners that was granted EU-funding to develop and demonstrate energy efficient cities and to build a methodology and tools for cities, industries and citizens to reach the 20-20-20 targets. • The success of the technology implementation also depends on the involvement of citizens. A serious game will be created to engage citizens in an innovative way in the development of their smart city.
OptEEmAL [2015 – 2019]	• Title: Optimised Energy Efficiency design platform for refurbishment at district level • Objective: to develop an Optimised Energy Efficient Design Platform to improve the energy behaviour of a district. • The tool will reduce time delivery and uncertainties and result in improved solutions when compared to business-as-usual practices.

NewTREND [2015- 2018]	• Title: New integrated methodology and Tools for Retrofit design towards a next generation of ENergy efficient and sustainable buildings and Districts • Objectives: - Develop an integrated design methodology for energy retrofit - Address all phases of the refurbishment process (concept design to implementation and operation) - Develop a toolkit to support each phase - Foster collaboration among stakeholders and involve building inhabitants and users - Establish energy performance as a key component of refurbishments - Cover detailed design of one-two buildings taking into account interactions with the surrounding neighbourhood - Facilitate the use of BIM for retrofit.
CONCERTO [2005 – 2014]	• Aims at demonstrating that the energy optimisation of districts and communities as a whole is more cost-effective than optimising each building individually • Consisted of projects in 58 communities in 23 countries that ran from 2005 to 2014.

Note: My Smart City District group (MSCD) is an eight-project consortium that contains most of the above-mentioned projects (EU-GUGLE, R2CITIES, ZenN, CITyFIED, Sinfonia, READY, City-zen and Celsius). Its goal is to cluster a number of their activities to share and promote energy efficient renovation solutions for cities and communities EU-wide.

4.6 Concluding assessment

District approaches to the renovation of existing buildings consist of comprehensive approaches that aim at renovating not only single building units, but rather a district or a neighbourhood at the same time. District approaches will help to tackle three key challenges regarding renovation of existing buildings in the EU: developing integrated approaches maximising the synergies between energy efficiency and renewable energy, streamlining and aggregation of renovation solutions and processes, and developing comprehensive (sub)urban strategies combining energy and carbon efficiency of the building stock with sustainable solutions for growth and improvement of citizens' wellbeing.

The following conclusions are based on the analysis of policies in 18 countries and 5 regions and additional research on local and international initiatives.

District approaches to efficiently unlock the renovation of the building stock are relatively new in political agendas and the scale of implementation can be very local. Hence, existing national and regional legislation is scarce. Where initiatives exist, they are often at the stage of assessing the requirements and benefits of such approaches. Exceptions exist, and some pioneering provisions have been highlighted.

Even though provisions that aim to streamline and aggregate renovation solutions and processes at neighbourhood level are fewer in number compared to policies addressing other challenges, they are generally strongly related to the renovation of existing buildings at the district level. While the two other key challenges (i.e. integrated EE/RES approaches and comprehensive (sub)urban strategies) are better addressed in terms of quantity of policy instruments, these are generally less targeted to the renovation of the building stock.

Regarding integrated approaches to maximise both EE and RES potentials, three main types of initiatives were identified: district heating developments, local/regional mapping of renewable heat potentials, and energy communities. Provisions aiming to streamline and aggregate renovation solutions are mainly initiatives and studies exploring the strengths and weaknesses of such approaches, but the results of those initiatives have tremendous potential for future replication and scaling up. Finally, most provisions regarding comprehensive (sub)urban strategies can be clustered into three types: infill[20] strategies and rehabilitation of buildings, sustainable urban energy efficiency plans, and sustainable urban planning projects encompassing energy efficiency, RES and health benefits (new builds).

Recent international projects bring valuable insights on the required components to enable and foster district approaches to energy renovation of existing buildings. They also provide a series of pilot cases, methodologies and tools to support the development and dissemination of district approaches. Most of these ended a few months ago. The challenge lies in the dissemination and replication of their results.

[20] In urban planning, infill is the rededication of land in an urban environment, usually open space, to new construction.

Assessment of impact per type of policy instrument

A broad range of policy instruments is needed in order to mainstream district approaches for renovation. Allowing for the integration of both cost-efficiency and social considerations, district approaches need to boost the renovation of the existing building stock and the deployment of renewable energy solutions. Given the early stage in the development of district approaches for renovation in the EU, a quantitative impact assessment cannot be provided here. Instead, the role of each type of instrument is discussed, as illustrated in Figure 4.

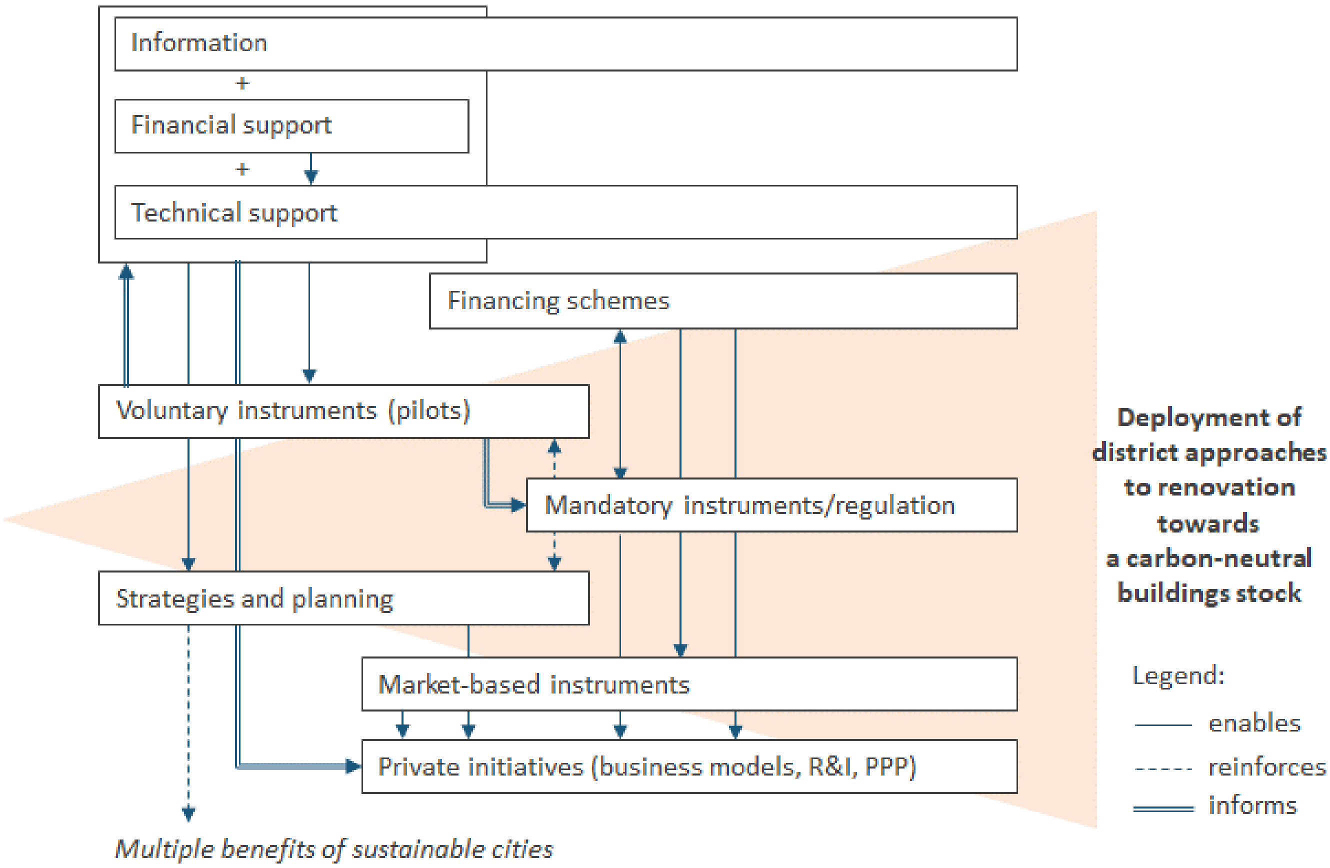

Figure 4. Interactions between policy instruments for the deployment of district approaches to the renovation of the existing building stock

Information and awareness raising will play a major role in the deployment of district approaches. In particular, awareness raising and capacity building of local administrations on the benefits of such approaches are indispensable for the emergence of district-scale renovation projects. Appropriate information combined with financial support can trigger voluntary actions (pilot projects, sustainable district certification schemes, etc.) that demonstrate the benefits and stimulate innovation in business models, tools and financing models. Improved data on the building stock will also support private initiative developments of innovative solutions for group renovations of specific buildings segments.

Technical support: District-level initiatives involve a large number of stakeholders from different sectors as well as different building types and ownerships. While information and awareness raising can trigger interest, effective results depend on the development and dissemination of the tools required for such approaches (for the stakeholder engagement and decision-making processes, the techno-economic design, etc.), and the implementation of specific roles for the activation and facilitation of district-level renovations. Again, the availability of financial support can enable such technical support instruments.

Financial support such as subsidies can create an economic incentive to trigger investments both on the demand side and on the supply side. More importantly on the demand side, financial support will help to bring the required technical support to local stakeholders and help facilitate participation processes. On the supply side, it can support private pioneer actors in developing innovative solutions.

Voluntary instruments (private pilot projects, voluntary certification schemes, large-scale renovation of public buildings) are crucial to demonstrate the benefits of district-level approaches and build capacity of all stakeholders with these approaches. District approaches are inherently deeply impacted by the local context with specific stakeholders and characteristics of the building stock. Careful analysis of success and failure factors is crucial to maximise the impacts of the district-scale renovation projects triggered by voluntary (and surrounding) instruments.

Strategies and planning maximise benefits and increase positive synergies (possibly reducing the total required investments). Appropriate energy planning tools[21] allow projects to go beyond technical and economic criteria, integrating social considerations.[22]

Mandatory instruments at the local level (e.g. targets such as average energy efficiency level, RES contribution or maximum levels of greenhouse gas emissions, or through means such as regional or local heat plans) can foster the integration of energy and climate objectives in local planning and strategies. They can also trigger discussion between local stakeholders and lead towards cost-optimal solutions at district level (generally better than the sum of individual cost-optimal solutions). Furthermore, legislative instruments can mandate such integration of land-use and energy planning to capture, amongst others, the potential of densification to connect sustainable mobility, buildings energy renovation and revitalisation challenges.

Financing instruments provide the ability to invest, but only apply where there is already a need or desire to take measures. While district approaches can drive the mobilisation of investments (such as higher investment volumes and diversified risk portfolios) they also bring specific challenges to be addressed by financing schemes for the feasibility of community projects.

Market-based instruments were not identified in the country analysis behind this factsheet, nor in the literature review. However, minimum energy efficiency requirements applied to individual buildings are expected to affect prices on the real estate market. Likewise, mandatory targets framed at the local level could impact this price signal and foster district/neighbourhood approaches.

Private initiatives (e.g. business model innovation, innovation in renovation products and processes, large-scale private investments in the renovation of groups of private or public buildings) will be made possible through facilitated demand markets, quality data on the building stock and mandatory instruments that provide certainty and clear targets.

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[21] InSMART: Integrative Smart City Planning

[22] European Alliance to Save Energy, 2020. Recommendations for a neighbourhood approach to maximize energy efficiency in renovation and energy planification.

In order to scale up innovation, both an improvement of the conditions for innovation on the supply side and market demand for innovative decarbonisation solutions are needed.[23]

In conclusion, information and technical support combined with financial support and innovation are seen to deliver a binary impact, i.e. nothing will be achieved unless significant efforts are devoted to deploying such instruments. They are the ground for voluntary instruments that provide the needed learning and demonstration lab. Strategies and planning embedding RES, energy efficiency and carbon targets together with the broader challenges in the development of sustainable cities will help to identify the local resources, constraints, and synergies to lower the costs and maximise the multiple benefits of buildings energy renovation projects. Building on this ground, mandatory instruments can be framed to encourage district approaches to renovation but will only be actionable if adapted financing schemes are mainstreamed. The paradigm shift for renovation, from individual building units to groups of neighbouring buildings, can be further supported by private initiatives, steering innovation on the whole supply chain and the mobilisation of private investments.

Based on our review of existing policy instruments, we conclude that Member States mainly implement single policies out of this broad set of possible instruments (with strategies and planning, and financing instruments being the least considered). Guidance on the implementation of comprehensive policy packages to foster district-scale renovation projects would certainly help to strengthen the efficiency of existing policies.

Ease of implementation per type of policy instrument

There is still an important gap in capturing the potential of district approaches. This final section briefly discusses the possible efforts of the EU Commission to fill this gap.

Information and awareness raising is probably the biggest challenge in terms of efforts for all political levels. Efforts at the EU level could focus on targeting local government and enable them to disseminate information and raise awareness toward their local stakeholders. This could be done via specific workstreams dedicated to district approaches for renovation in initiatives such the Covenant of the Mayors or the Positive Energy Districts (PED) programme. This will be usefully supported by communications on best practice examples, distinguishing between generic and context-specific success and failure factors.

The required technical support (accompaniment and tools) can be structured based on the learnings from a short list of (recently closed and ongoing) EU-funded projects and international initiatives focusing on district approaches to renovation. This support can be brought to local stakeholders via a combination of central (EU) and decentralised groups of technical experts, together with the financing of this expertise.

The PED programme – aiming to support the planning, deployment, and replication of 100 Positive Energy Neighbourhoods by 2025 and coordinated by JPI Urban Europe – is an important initiative to raise awareness, increase knowledge and trigger voluntary initiatives.

Comprehensive strategies and planning require stakeholder participation, which can be enabled through tried-and-tested facilitation processes, tools and frameworks. The

[23] CE Delft, 2020. Zero carbon buildings 2050

integration of different objectives in the development of sustainable cities into holistic strategies and planning could be fostered by national legislation, mandated or encouraged at EU level.

Mandatory instruments certainly need strong political commitment, should be affordable (enabled amongst others by innovation, financing schemes and financial support) and depend on the availability of technical support. Article 19 of the revised Energy Performance of Buildings Directive (EPBD) indicates that, by 1 January 2026 at the latest, "the Commission shall examine in what manner Member States could apply integrated district or neighbourhood approaches in Union building and energy efficiency policy, while ensuring that each building meets the minimum energy performance requirements, for example by means of overall renovation schemes applying to a number of buildings in a spatial context instead of a single building." Moving in that direction, a clear definition of a neighbourhood approach should be established, e.g. specifying the ratio of worst-performing buildings in a given area to be renovated, to avoid a 'pick and choose' approach where only buildings that are easier to renovate are part of the district renovation strategy.[24] District approaches transposing the EPBD, as found in the new German law on energy in buildings, need to be evaluated carefully to make sure they are not watering down renovation ambition compared to previous legislation.[25]

Finally, private initiatives could be facilitated by the creation of innovation ecosystems connecting different actors in the innovation value chain, including universities, technology suppliers and construction companies. They can also be triggered by large-scale renovation programmes of public buildings that could be fostered or mandated at EU level.

[24] European Alliance to Save Energy, 2020. Recommendations for a neighbourhood approach to maximize energy efficiency in renovation and energy planification.
[25] The so-called "Innovationsklausel" (§103 Gebäudeenergiegesetz) allows the previously existing minimum efficiency requirements for new buildings to be fulfilled at the district level, thereby lowering the minimum requirements for individual buildings.

Engaging transformation and phasing out inefficient buildings –Factsheet

Authors: Janne Rieke Boll, Rutger Broer, Sibyl Steuwer, Jonathan Volt

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5.1 Introduction

This factsheet provides an overview of how different policy instruments and selected private initiatives can help to achieve European objectives and effectively address key EU challenges in the strategic area of **engaging transformation**. The findings draw upon a policy screening for 15 EU Member States, 3 non-EU countries and 5 European regions covering broadly the climatic zones of the EU. In addition, the factsheet draws on additional information provided by external experts as well as on the long-standing expertise of the authors, meaning policy examples going beyond the researched country and region cases are occasionally added. The concluding assessment draws on the findings and detailed analysis of the good practice cases as well as on the in-house expertise of the partners.

5.2 Engaging transformation and phasing out inefficient buildings

Engaging transformation and phasing out inefficient buildings is at the core of achieving a decarbonised building stock in the EU. Some 40% of EU energy consumption and 36% of its CO_2 emissions are related to buildings.[26] Renovating the least efficient buildings in the EU can contribute to bringing down these figures significantly. To establish a deep-retrofit market to decarbonise the building stock, certain key challenges need to be overcome:

1. Create an enabling framework for deep renovations that are currently not cost-effective.
2. Trigger behavioural change and acceptance of deep energy renovation among building owners and occupants.
3. Accelerate the market penetration of innovative solutions for deep energy renovations
4. Achieve deep renovations in a heterogenous building stock with mixed ownership.

The following sections provide:

- A summary and specification of selected policy instruments that have been scanned for in each country/region covering instruments to phase out the worst-performing building stock and introduce building renovation passports, one-stop-shops and information instruments.
- An overview of the policy mix (both legislative and non-legislative) in place to address the key challenges mentioned above in all 23 countries and regions.
- A shortlist of good practice examples.
- A concluding assessment analysing the impact and transferability across all types of policies.

5.3 Provisions to address key challenges

This section gives an overview of the policies considered to be most successful at tackling key challenges in the area of engaging transformation. To operationalise the challenges and allow for quantitative estimations on selected aspects, the country screening looked for provisions including instruments to phase out inefficient buildings, building renovation passports, and provisions to set up one-stop-shops (OSS).

[26] European Commission. (2019). Link

A broad spectrum of policy instruments is applied across the EU to address the key challenges in this strategic area. Table 5 provides an overview of a selection of key policy instruments assessed for all targeted jurisdictions. These policy instruments are rather novel and address important gaps in the policy mix.

Policy instruments to phase out inefficient buildings refer to a variety of regulations, programmes, (financial) schemes and strategies that Member States implement to renovate the worst-performing buildings. A distinction is made between mandatory instruments and non-mandatory instruments.[27]

Mandatory instruments

Almost all countries have implemented forms of mandatory instruments to phase out inefficient buildings, e.g. the obligation to upgrade the energy performance of a building when major renovations take place. Most of the time, these instruments are transposing the requirements of Article 4 (and Article 7) of the Energy Performance of Buildings Directive (EPBD), but do not go beyond. Only in a few countries do provisions go beyond EPBD requirements, in particular the Minimum Energy Efficiency Standards[28] for private rented property in England and Wales, minimum performance requirements in Flanders,[29] Mandatory Renovation in Brussels,[30] EPC level C for office buildings larger than 100m^2 in the Netherlands by 2023[31] and Minimum Energy Performance for Buildings in France[32]. In certain countries specific mandatory minimum requirements apply to public buildings transposing Article 6 of the Energy Efficiency Directive into national legislation, for example in Brussels[33] and Spain[34], where public buildings can only be purchased or leased if they obtain an EPC label of C or better.
Another type of mandatory measure is the phasing out of fossil fuel-fired heating boilers, which a growing number of European countries have put/are putting in place. Mostly, it applies to oil-fired boilers in new buildings (Brussels, Flanders, some Austrian regions, Germany). Ireland also includes a ban on gas-fired boilers[35], the UK includes all fossil-fuel-based heating and the Dutch government decided to phase out gas use for heating in new buildings from 2020. In Poland, the frontrunner Krakow and the Malopolska region decided to phase out coal-fired boilers in 2013 (in force since 2019) inspiring other Polish regions to set up minimum emissions standards, thereby not only reducing CO_2 emissions

[27] Mandatory instruments include minimum performance requirements for existing buildings or renovation regulations that go beyond European requirements. Among non-mandatory measures, the focus is on the renovation of the worst-performing building segments and measures taken to incentivise the renovation up to a certain building performance standard (e.g. EPC class). The non-mandatory instruments can also include financial support, as well as programmes to renovate inefficient buildings in vulnerable areas (e.g. many energy-poor households).
[28] The Energy Efficiency Regulations (2015). Minimum Energy Efficiency Standard (MEES) for private rented property in England and Wales.
[29] Minimum performance requirements in the Flemish Building Code (2019). Mandatory insulation levels for roofs by 2020 and windows by 2023. Regulation. Art 39.
[30] Strategy to reduce environmental impact of buildings Brussels (2020). Mandatory renovations at 5-year intervals to achieve decarbonisation in 2050. LTRS, p42.
[31] EPC level C for office buildings - Bouwbesluit (2012). Obligation for offices larger than 100m2 must achieve EPC C in 2023. Link regulation,
[32] Minimum energy performance buildings. (2015). France. Minimum requirements for rented properties in residential and non-residential sector. Article 12.
[33] EE standards for rented or purchased public buildings (2013). Ordinance of Air, Climate and Energy Management. Art. 2.1 Anex 2.1
[34] Law on the rationalization of the public sector (2014). EE requirements for procurement of goods and buildings of public authorities.
[35] Government of Ireland (2019) Climate Action Plan, p. 82

but also air pollution.[36]. In 2016, Denmark banned oil-fired boilers for existing buildings when there is the opportunity to connect to district heating. In Norway, from 2020, the use of oil-fired boilers is banned for all existing buildings.

Non-mandatory instruments

Non-mandatory instruments to phase out inefficient buildings often take the shape of financial support linked to energy efficiency in specific building renovation programmes. One example is Lithuania's renovation (modernisation) of multi-apartment buildings programme[37] which aims to renovate a large share of its apartment buildings up to the EPC level C. In France, through subsidies for replacing old and inefficient oil (and gas) boilers, the government aims to achieve zero oil boilers in the next 10 years.[38] Another example is a grant for residential building renovation with free energy advice for A+++ renovation in Baden-Württemberg[39]. Examples for other instruments include the facilitation of energy-efficient renovation to an EPC level A in case of a major renovation for the social housing sector in Brussels[40] and a programme to renovate worst-performing schools (with an EPC level G) by 2022 in the Netherlands.[41] In Finland, buildings with energy classes F and G can benefit preferentially from the energy subsidy scheme, which can also be combined with a demolition subsidy for vacant and poor quality buildings.

Building renovation passports (BRPs) are documents (paper or digital) that outline a stepwise roadmap with renovation measures tailored to individual buildings with a 15-20-year timeline.[42] They aim to help to align renovation according to individual needs and long-term requirements.

BRPs are not yet widespread across Europe. Currently implemented BRPs are the Flemish Energy Performance Certificate [Belgium][43], the local Energy House Passport [France][44] and private Energy Efficiency Passport [France][45], the Individual Renovation Plan [Germany][46], as well as pilots tested in the iBRoad project (with pilots in Poland, Portugal, Germany, Bulgaria and stakeholder engagement in Greece, Romania and Austria).[47] Ireland is currently piloting a building renovation passport[48], based on the iBRoad model.

One-stop-shops for energy renovation of buildings cover the complete customer journey from the monitoring of savings, structure and provision of financial support and technical

[36] RESOLUTION No. XVIII/243/16 of the SEJMIK OF THE MAŁOPOLSKIE VOIVODSHIP of 15 January 2016 on the introduction of restrictions on the operation of installations where fuels are burned in the area of the Municipality of Kraków" https://bip.malopolska.pl/umwm/Article/get/id,1159347.html
[37] Renovation (Modernisation) of multi-apartment buildings. (2021-2030). Lithuanian National Energy and Climate Plan. Lithuanian government. p146
[38]https://www.ecologique-solidaire.gouv.fr/communique-presse-francois-rugy-et-julien-denormandie-annoncent-lancement-progressif-prime
[39] Support Programme for Climate Friendly Housing (2020). Freiburg. Free Energy Saving at Home A+++
[40] Strategy to reduce environmental impact of buildings Brussels (2020). Energy performance of social housing. P47
[41] The Building Agenda (2017). Roadmap sustainability of schools. Target: schools with EPC-G renovated before 2022.
[42] BPIE (2018). . Link
[43] The Flemish EPC has been updated to include a building renovation passport.
[44] European Commission (2019). Technical study on the possible introduction of optional building renovation passports
[45] P2E. (2017). Energy Efficiency Passports. Passeport Efficacité Energétique (P2E).
[46] BPIE. (2017). Building Renovation Passports. Individueller sanierungsfahrplan.
[47] IBroad, pilot implementation of BRP in Greece, Poland and Portugal. H2020 project.
[48] IGBC (2019). Building Renovation Passport Pilot. Irish Green Building Council and Limerick Institute of Technology.

assistance to information provision.[49] For clients, they are an accessible and transparent tool to select and commission renovation measures, while for suppliers in the renovation sector they provide opportunities for innovative business models.

While many countries have attempted to provide aggregated services for renovation, fully-fledged one-stop-shops including the provision of financing are not yet in place throughout Europe. Picardie Pass Rénovation in France was a pioneer in integrating third-party financing in its OSS model for homeowners. RenoWatt in Wallonia[50] facilitates renovations of public buildings through simplified tendering procedures, financial packages including energy performance contracting and aggregation of projects. The public Bedre Bolig Scheme[51] and private BetterHome, both in Denmark, use publicly available building data to trigger energy renovation projects. Superhomes [Ireland][52] and Oktave [France] focus solely on the deep renovation of single-family houses, while Operene [France] does the same for larger buildings. ProEnergyHomes in Ireland uses energy efficiency obligations in its OSS to compile an attractive offer.

[49] JRC (2018) Link

[50] RenoWatt, Wallonia, is an OSS for public buildings specialised in energy audits, technical studies and energy performance contracting.

[51] The Bedre Bolig scheme. Law 1876. Denmark. Facilitates OSS through an amendment on the promotion of energy savings in building.

[52] Superhomes in Ireland is a OSS that offers cost-effective building performance measures in an integrated solution

Table 5 - Overview of selected instruments adopted in the jurisdictions analysed[53]

Country/ Region	Instruments to phase out inefficient buildings		Building renovation passports	Provisions to set up OSS
	Mandatory	Voluntary/recommended		
Andalusia		√		
Baden-Württemberg		√		
Brussels	√	√	√	√
Flanders	√	(√)	√	√
Wallonia	√	(√)	√	√
Croatia		√		
Denmark				√
France	√	√	(√)	
Germany		(√)	√	(√)
Greece		√	(√)	
Ireland		√	(√)	√
Italy		√		
Lithuania		√		
Netherlands	√	√		
Norway				
Poland			(√)	

[53] Check marks within brackets indicate that there are measures that only partially comply with the definition provided above.

Portugal		(√)	(√)	
Romania				√
Silesia				
Spain		√		
Sweden		√		
Tirol		(√)		
UK	√			
Umea		√		
USA	(√)			

If we group the existing policies in three categories (regulation[54], financial measures[55], and informative measures[56]) most countries have adopted a mix of policies, some privileging informative measures (e.g. Portugal, Romania, Spain) over financial support (e.g. Croatia, Germany, Ireland, but also most regions) or regulations (e.g. France, Greece, Belgium, Poland).

While all analysed countries and regions have implemented forms of financial measures to stimulate the renovation of inefficient buildings, the financial support for renovation is mostly not targeted at the worst-performing building stock in particular, but at certain segments of the buildings stock (e.g. all residential buildings, all buildings with co-ownership, etc.). The long-term renovation strategies (LTRS) submitted in 2020 show that Member States have generally got better at identifying the worst-performing building stock. However, this does not always translate into clear policies to renovate these buildings. Informative measures represent an important share of measures in many countries. This indicates that raising awareness and sharing knowledge is relatively easy to implement. It can become an effective way to trigger acceptance by building owners, inhabitants and construction professionals if part of a wider policy mix including financial support and mandatory instruments.

5.4 Overall assessment for effectiveness - overview and description

This section presents an assessment of the overall policy landscape that a previous country screening identified as relevant for the covered countries and regions. The assessment takes into account the diversity of instruments (regulation, pricing, support, information etc.), whether there are particularly interesting and innovative instruments, and whether the instruments identified together seem to be adequate to address the given challenges. The overview tables are followed by a discussion of policy instruments.

The given classification in Table 6 and Table 7 should be interpreted as follows:

	Good policy landscape with at least one innovative instrument targeting engagement
	Adequate policy landscape with instruments that could in the future better integrate engagement in building renovation policies

[54] *Regulations* here entail mandatory performance requirements, sections with minimum performance requirements and technical standards in the building code, mandatory public procurement policies about renting properties, obligations to save energy (public/private), and bans on fossil heating sources.
[54] *Financial measures* relate to financing renovation of inefficient buildings, mostly consisting of grants, subsidies, ESCO financing schemes, tax rebates and public/private financing.
[54] *Informative measures* are policies designed to enhance awareness, knowledge generation and dissemination. This includes energy performance certificates, one-stop-shops, building renovation passports, environmental/energy efficiency certification or labels, awareness campaigns and guidance documents, free or subsidised energy audits, (digital) knowledge sharing platforms or tools, and training and education programmes.

	Inadequate policy landscape, with no instruments identified in relation to the given challenges
	Not conclusive

Table 6 - Legislative policies

	Engaging transformation - legislative policies			
	KEY CHALLENGES			
	Create an enabling framework for deep renovations that are currently not cost-effective	Trigger behavioural change and acceptance of deep energy renovations among building owners and occupants	Accelerate the market penetration of innovative solutions for deep renovations	Achieve deep energy renovations in an heterogenous building stock with mixed ownership
Belgium				
Croatia				
Denmark				
France				
Germany				
Greece				
Ireland				
Italy				
Lithuania				
Netherlands				
Poland				
Portugal				
Romania				
Spain				
Sweden				
UK				
Norway				
USA				
Andalusia				
Tirol				
BW				
Silesia				
Umea				

Table 7 - Non-legislative policies

	Engaging transformation – non-legislative policies			
	KEY CHALLENGES			
	Create an enabling framework for deep renovations that are currently not cost-effective	Trigger behavioural change and acceptance of deep energy renovations among building	Accelerate the market penetration of innovative solutions for deep renovations	Achieve deep energy renovations in an heterogenous building stock with mixed ownership

		owners and occupants		
Belgium				
Croatia				
Denmark				
France				
Germany				
Greece				
Ireland				
Italy				
Lithuania				
Netherlands				
Poland				
Portugal				
Romania				
Spain				
Sweden				
UK				
Norway				
USA				
Andalusia				
Tirol				
BW				
Silesia				
Umea				

1) Create an enabling framework for deep renovations that are currently not cost-effective

To reach the European long-term targets for climate protection in the building sector, measures that are not yet cost-effective from a purely financial perspective will have to be implemented. While both the current regulatory framework in the EU as well as policies in several Member States are mostly focused on implementing cost-effective measures, there are still numerous provisions in place that promote deep renovation.

While **mandatory requirements** rarely go beyond EU requirements (for exceptions, see above), all countries and regions have **financial support** in place to encourage deep renovation (see also factsheet on financing renovation). Some grant schemes are performance oriented and provide (close to) sufficient financing for climate-proof renovation. One of the most prominent schemes is the German KfW energy efficient renovation[57] programme which was recently updated and topped up with additional grants and better loan conditions. It is combined with the KfW Energy Efficiency Standard[58] to provide more funding for very efficient renovations.

The availability of funds at the regional level varies. While there are regions with only limited grants available at the local level dedicated to carrying out deep energy renovation (e.g. the Catching-Up 2 Regions programme in Silesia[59] promotes renovation to fight smog), there are others that offer a wide range of grants. An example is Tirol with several regional grants to support energy renovation[60] in the building sector that can be complemented by other local grants, e.g. the municipal grant offered in the city of Innsbruck. Both programmes provide additional support (Ökobonus) for deep renovation and also support renewable building material[61]. Another example is the renovation programme in Pays Voironnais in France[62] to renovate condominiums. In certain jurisdictions, these programmes are tailored to social housing or buildings in socio-economically disadvantaged areas, like for example the Better Energy Communities and Energy Efficiency Retrofit Programme in Ireland[63][64], the Support for Housing Associations in disadvantaged areas in Sweden, Umea[65] and the Saving at Home programme II in Greece[66]. In Spain's National Housing Plan, Spain[67] loans and grants for energy-efficient

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[57] KfW Programm 151, 152 „Energieeffizient sanieren – Kredit" (2020), https://www.kfw.de/PDF/Download-Center/F%C3%B6rderprogramme-(Inlandsf%C3%B6rderung)/PDF-Dokumente/6000003743_M_151_152_EES_Kredit_2018_04.pdf, KfW Programm 430 „Energieeffizient sanieren – Investitionszuschuss" (2020) https://www.kfw.de/PDF/Download-Center/F%C3%B6rderprogramme-(Inlandsf%C3%B6rderung)/PDF-Dokumente/6000004311_M_430_Zuschuss.pdf

[58] KfW Energy Efficiency Standard. (2020). KfW Group. Germany.

[59] Catching-up 2 Regions. Fight against smog: financial instruments for increasing the energy efficiency of single-family buildings)", URL: https://powietrze.slaskie.pl/content/projekt-poland--catching-up-regions

[60] Land Tirol: Wohnhaussanierungsrichtlinie (2020), URL: https://www.tirol.gv.at/fileadmin/themen/bauen-wohnen/wohnbaufoerderung/downloads_2019/ws-richtlinie_01-01-2020.pdf

[61] Landeshauptstadt Innsbruck: Innsbruck fördert: energetische Sanierung (Zusatzförderung zur Wohnhaussanierungsrichtlinie des Landes Tirol), URL: https://energie.innsbruck.gv.at/data.cfm?vpath=subsites/energie1/dokumente42/sanierungsfoerderung

[62] Renovation in Pays Voironnais (2013-2017). Communauté d'Agglomération du Pays Voironnais. ADEME and the Ministry of Environment and Energy. p37

[63] Better Energy Communities (2019-2020). Sustainable Energy Authority of Ireland.

[64] Energy Efficiency Retrofitting programme (2013-2019). Irish Department of Housing, Planning and Local Government.

[65] Energy Renovation in Vulnerable Areas (2017-2018). Swedish National Board of Housing Boverkets.

[66] Saving at Home Programme II. Energy Efficiency Trends and Policies in Greece. Centre for Renewable Energy Sources and Saving Greece. p29

[67] National Housing Plan 2018-2021. Spain. Royal Decree 106/2018.

building renovation linked to achieving a certain level of EPC are combined with specific programmes to support vulnerable groups (e.g. youth and elderly).

While all countries have **informative measures** in place to highlight the benefits of deep renovation, there is little well-targeted information available about benefits and the long-term necessity of measures that are not yet cost-effective for the owner. BRPs and general energy renovation guidelines by governments are exemplary measures that contain information on the necessity to reach long-term renovation targets. The definition of cost-effectiveness mostly does not include wider benefits and follows mainly conservative approaches to define economic efficiency. Exceptions to this are the planned initiative to reform the cost-effectiveness calculation to include wider benefits in Wallonia[68] and the update of criteria to renovate public buildings for federal buildings in Germany, now also allowing for deep renovation that is not yet cost-effective.

Deep energy renovation of heritage buildings while preserving their cultural value is a challenge that is acknowledged in a variety of policy instruments. The KfW programmes specify exceptions for technical requirements for heritage buildings ("Effizienzhaus Denkmal"). Ireland's Sectoral Adaptation Plan – Built and Archaeological Heritage[69] addresses the twin challenges of reducing the energy consumption of heritage buildings and enhancing their climate resilience at a strategic level. In Croatia, the energy renovation programme for buildings with cultural heritage status[70] is especially dedicated to finding energy renovation solutions for these buildings.

2) Trigger behavioural change and acceptance of deep energy renovations among building owners and occupants

Initiatives to change the behaviour of building owners, occupants, investors and other actors are becoming more common across the EU.

The **Energy Performance Certificate**, now introduced in all Member States (and in the UK and Norway) as mandated by the EPBD, is widely used to influence behaviour and has the potential to become the most effective instrument to do that if improved and supported by other measures. Flanders has evolved its EPC framework into a building renovation passport, with step-by-step renovation advice making sure the suggested measure is logical in the short and the long term. Some countries have also modified their EPC to become more attractive or user-friendly. The energy performance of the building envelope is shown in the Italian EPC with qualitative "smileys", indicating its ability to thermally insulate the building. On the front page of Portugal's EPC, figures showing the building's renewable energy use and CO_2 footprint are presented. Several Austrian regions, e.g. the Salzburg region, have established a regional EPC database ZEUS.

The energy expert/advisor can play an important role as "promoter" of the idea of deep energy renovations. The expert earns the owner's trust by providing objective and easy-to-understand information and personalised support on what a rational approach for their

[68] Draft Walloon Long-Term Strategy for Energy Renovation of Buildings (LTRS) (April 2020) - Chapter IV.C, Action 41.1

[69] Department of Culture, Heritage and the Gaeltacht (2019) Built & Archaeological Heritage - Climate Change Sectoral Adapta on Plan. https://www.dccae.gov.ie/documents/Built_%20and_Archaeological_Heritage_Climate_Adaptation_Plan.pdf

[70] Ministry of Environment and Energy (2019) Integrated National Energy and Climate Plan for the Republic of Croatia for the period 2021-2030, p. 140

energy renovation might be. Project Zero in Sonderborg, Denmark has, among other **one-stop-shops**, shown that this approach motivates a far larger share of owners to choose an energy renovation than in cases with only a financial incentive. Frontrunner cases (the Individual Renovation Plan in Germany, Picardie Pass Rénovation in France or the German energy audits scheme) have shown that **tailored and personal renovation advice** triggers building owners to renovate deeper and choose higher-performing components.[71]

Several online tools exist to assist building owners to become more energy efficient. The National Digital Platform in the Netherlands helps homeowners to make their home more sustainable. The platform also makes links to providers and financiers. Other examples were presented under the section on one-stop-shops above.

The most common form of instruments to trigger acceptance and behavioural change are **communication and awareness campaigns**. Prominent examples are the digital training for landlords and tenants on green leases [Sweden][72], energy efficiency campaigns for public real estate managers [Portugal][73], the Deutschland macht's effizient [Germany], and the Big Energy Saving Week [UK][74]. The Flemish "Ik BEN mee" campaign promotes nearly zero-energy buildings to different actors in the value chain as well as building owners. In Croatia, an instrument including an energy service model aims to raise awareness of energy renovations.[75] The ecotirol [Austria] is an advisory service informing the region on various topics, including energy renovation. In Ireland, Home Energy Savings Kits, including all tools to assess the residential energy performance, were available free-of-charge in public libraries. An education and information campaign in Silesia, Poland, linked to LIFE, is addressing all residents in the region.

Some countries provide practical guides to illustrate the potential of energy renovations. The Spanish "Practical guide to energy for building renovation" provides detailed information to homeowner associations. In Germany, advisory services for private individuals are available, free or for a small fee, across the country.

Other jurisdictions use training programmes to get different actors to grasp and promote the value of deep energy renovations. Examples include digital training on hiring ESCOs and energy management [Spain],[76] and the training programmes for residential energy consumers [Italy][77], the extensive expert training [Tirol, Austria] and the Energilyftet [Sweden], a web-based training programme aimed at building performance professionals. The ADENE Academy in Portugal seeks to reinforce the professional skills and qualifications of technicians, which is needed for a transition towards deep renovations.

Actions are also being taken to **improve awareness in the public sector**. Some countries focus on transparency of public building data to trigger additional energy-saving measures. Portugal's Energy Efficiency Barometer was launched to characterise, compare and disseminate the energy performance of public entities. In Denmark, the energy use of the different ministries is publicly available, together with information on what measures

[71] European Commission (2019) Technical study on the possible introduction of optional building renovation passports.
[72] Web training Green Leases. (2018). Sweden. Swedish Energy Agency.
[73] EcoTalks. (2018). Portugal. Awareness campaign about EE. ADENE.
[74] BESW (2020). UK. Advice about energy efficiency. Ministry for Business, Energy& Industrial Strategy.
[75] Croatia NEEAP (2017) Fourth National Energy Efficiency Action Plan of the Republic of Croatia for the Period from 2017 to 2019
[76] Digital E-learning platform. Spain. Spanish National Energy Efficiency Action Plan (2017-2020). P87
[77] Training for energy customers. (2014). Italy. Italian National Energy and Climate Plan (2019). P34

they have implemented. The Action Plan for Energy Efficiency in Public Buildings in the Autonomous Community of Arago, Spain trains public sector staff about energy efficiency in an effort to lead by example. Similarly, Brasov in Romania collects real-time energy data in municipal buildings and uses this information to raise awareness among staff.

Networks can also be a trigger for behavioural change regarding deep energy renovations. BEBO in Sweden is a network of larger multi-family building owners (private and public), in which they aggregate projects and exchange knowledge and experiences. Similarly, the Knowledge and Innovation Platform in the Netherlands is a network to share information and best practices on making public buildings more sustainable. In Andalusia, Spain, a network has been established to share experiences on energy efficiency to raise awareness and promote cooperation between local governments to achieve common objectives.

'Nudges' and other actions to influence people's energy consciousness are also becoming more common. The objective of the TRIBE project in Spain is to contribute citizens' behaviour change towards energy efficiency in public buildings, through their engagement in the experience of playing a social game.

3) Accelerate the market penetration of innovative solutions for deep renovations

Compared to the other challenges, comparatively fewer policy initiatives have been found throughout Europe to incentivise innovations and accelerate their market share.

The **business model to renovate buildings to a net-zero energy** standard making use of prefabrication and automation developed in the Netherlands (Stroomversnelling) has been transferred to other European countries under the label Energiesprong. In Baden-Württemberg, renovations with prefabricated facades are eligible to receive a specially tailored grant. The German government intends to implement a support programme for similar purposes until the end of 2020 parallel to supporting the German Energiesprong Initiative. The Realize-Initiative of the Rocky Mountain Institute brings the Energiesprong Initiative to America.

The City of Portland Green Building Policy [USA, municipal level] consists of an integrative approach including requirements not only for energy efficiency but also e.g. construction waste prevention, or pre-cabling and installing charging infrastructure in the planning phase.

One-stop-shops also help to accelerate the renovation of the building stock. Especially at the regional level, there are considerable initiatives implemented in France (e.g. Pass Rénovation [Région Hauts-de-France], Oktave [Région Grant Est]) and Ireland (SuperHomes, ProEnergy Ireland).

The Deep Retrofit multi-annual programme[78] in Ireland gathered experience on the challenges and opportunities of deep renovations of residential buildings. The lessons learned will feed into a new retrofit model to upgrade 500,000 homes at large scale under the Irish Climate Action Plan.

[78] Deep Retrofit Programme, Sustainable Energy Authority Ireland (SEAI), 2017-2019

In other countries, **innovative financing** schemes related to energy service companies (ESCOs) and energy efficiency contracting have been implemented, including the Programme for Energy Renovation of Public Buildings in Croatia[79] and Romania's PadovaFIT EXPANDED programme to renovate condominiums.[80] Another innovative financing instrument is the building-related financing in the Netherlands[81] which will allow the transfer of loans for energy efficiency measures to new owners when a property is sold.

4) Achieve deep energy renovations in a heterogeneous building stock with mixed ownership

Policy instruments to overcome the split-incentive dilemma include mandatory minimum requirements (MMR) that oblige the building owner to adopt a certain level of energy efficiency performance to ensure the building is marketable or complies with a certain energy performance level at a specific point in time.

The Dutch government discusses the right for tenants[82] to require their landlord to implement deep renovations, including reasonable rent increases which would alleviate the split-incentive dilemma. In Germany landlords can transfer a share of the costs[83] for energy efficiency improvements and modernisation to their tenants. An amendment of the Commercial Rental Act makes the same possible in Denmark[84] and the Wallonian government wants to develop a "warm rent" system according to its draft LTRS to keep rent and heating costs constant after renovations.

Energy service contracting is an approach to finance renovation that addresses the split-incentive dilemma and is used in various European countries. Energy service companies (ESCOs) offer energy efficiency improvement measures that are repaid through the energy costs saved. In Portugal, a general tender process was established in 2011 to support the public sector in setting up an energy service market. Italy's National Energy Efficiency Fund[85] supports measures carried out by ESCOs, while the Energy Efficiency Fund[86] in Ireland lends to ESCOs in order to support energy-efficient building renovations in the public and private sector. At the local level, under the Dublin Climate Action Plan, Dublin city council facilitated an energy performance contract for energy upgrades of public non-residential buildings and the Belgian region of Wallonia plans to develop the legal and regulatory framework of ESCOs[87] including a regional facilitating agency.

A consumer-centric, innovative approach to financing renovation works is the EuroPACE[88] integrated home renovation platform using on-tax financing to make long-term payback projects possible.

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[79] Programme for Energy Renovation of Public Buildings (2014-2015). National Energy and Climate Plan Croatia. Ministry of Environment and Energy. p34.
[80] PadovaFIT EXPANDED. (2019-2022) Metropolitan area of Timisoara. H2020.
[81] Building Related Financing (GGF) (2019) Climate Agreement. Amendment to the civil law is expected in 2020. p23. The Netherlands.
[82] LTRS, the Netherlands, p. 38
[83] Modernisation apportionment, German Civil Code, §559 „Mieterhöhung nach Modernisierungsmaßnahmen"
[84] Amendment of Commercial Rental Act, LTRS Denmark, 2017
[85] Fondo Nazionale per l'Efficienza Energetica [FNEE], Decree 22 December 2017
[86] Ireland Energy Efficiency Fund (IEEF) was launched by the Department of Communication, Climate Action and the Environment in 2014 and is managed by the private actor Sustainable Development Capital Limited (SDCL)
[87] Draft Walloon Long-Term Strategy for Energy Renovation of Buildings (LTRS) (April 2020) - Chapter IV.C, Measure 34
[88] EuroPACE Horizon 2020 project, 2018-2021, https://www.europace2020.eu/

The Romanian national thermal rehabilitation programme[89] addresses the issue of **mixed ownership in apartment buildings**. A French order[90] from 2012 required certain apartment buildings under co-ownership to carry out energy audits until January 2017 to initiate renovation projects, while information campaigns try to motivate condominium syndicates to renovate (e.g Renovation in Pays Voironnais, p.37). At the local level, French initiative mur I mur[91] funds co-owned apartment blocks built between 1945-1975. The Brussels LTRS plans to establish a co-ownership facilitator under the Sustainable Building Facilitator: this dedicated service for co-owned apartment buildings[92] to encourage renovation works intends to support at least 4% of co-ownerships per year by 2030.

[89] National program on increasing the energy performance of apartment buildings, government decision no. 18/2009, MINISTRY OF PUBLIC WORKS, DEVELOPMENT AND ADMINISTRATION, Romania
[90] Decree no. 2012-111 from 27 January 2012 relating to the obligation to carry out an energy audit for buildings for the main use of residential condominiums of fifty lots or more and to the thermal regulation of new buildings, Ministry of Ecology, Sustainable Development, Transport and Housing, France.
[91] Incentive campaign *Mur I Mur* by the Grenoble-Alpes Métropole, Auvergne-Rhône-Alpes, France
[92] Brussels capital-region LTRS, p. 96 (Action 22)

5.5 Highlighting good practice examples

Based on the results of the previous research as well as on expert knowledge, this section portrays selected good practice examples. Each example fulfils one or several of the following selection criteria: innovation (new mechanism, triggering innovation, scaling up innovation), impact (on EU objectives, energy savings, CO_2 emission reduction, potential renovation impact), ease of implementation (including transferability, scalability, transaction and administrative costs, budget (in-)dependency, compatibility with existing legislative/policy framework) and coverage of diverse jurisdictions and climatic zones.

Country	Policy	Brief description	Source
UK	Minimum Energy Efficiency Standard	• Establishes a minimum level of energy efficiency for privately rented properties (residential and non-residential) in England and Wales. These properties must have an EPC rating of E or higher to be rented out since 1 April 2018.	The Energy Efficiency Regulations (Private Rented Property) 2015. England and Wales
Brussels	Mandatory minimum requirement linked to a building renovation passport	• Mandatory renovations at five-year intervals to achieve decarbonisation in 2050. The requirements are linked to a building renovation passport setting out the renovation steps.	Strategy to reduce the environmental impact of buildings in Brussels (2020). LTRS, p42.
Germany/ Baden-Württemberg	Support serial renovation	• The Ministry of Environment, Climate and Energy in BW provides up to 40% of the costs per m^2 of residential buildings up to €500,000	Ministry of Environment, Climate and Energy. Baden-Württemberg. DENA. Energiesprong Germany. (2019)
Lithuania	Renovation [modernisation] of multi-apartment buildings	• Continuation of an existing renovation programme that aims to upgrade 5,000 multi-apartment buildings between 2021- 2030 to an EPC C rating.	National Energy and Climate Action Plan of the Republic of Lithuania for 2021-2030. p.146
Flanders	Digital Building Logbook	• The Flemish EPC for single-family homes has been updated to include a building renovation passport, including a renovation roadmap and cost estimates.	BEreel!. (2019). Belgium Renovates for Energy Efficient Living

Germany	Individual Renovation Map for Residential Buildings (iSFP)	• Renovation roadmap for individual residential buildings that details the steps the homeowner can take to decarbonise the building towards 2050.	German Energy Agency. (2016). iSFP
United States of America	New York City Building Emissions Law	• The New York City council has adopted a minimum mandatory requirement for various building segments based on a maximum carbon intensity per square metre.	Local Law 97. (2019). The City of New York
Denmark	Bedre Bolig	• Promotes energy efficiency in single-family houses, apartment blocks and other large buildings through a one-stop-shop approach in which homeowners can obtain a complete energy renovation package.	The Bedre Bolig scheme. Law 1876.
Ireland	Better Energy Communities	• Energy performance renovation grants for residential and non-residential buildings, providing higher grants to areas more vulnerable to energy poverty.	Better Energy Communities (2019-2020). Sustainable Energy Authority of Ireland
France	Picardie Renovation Pass	• Within the region of Picardie, the Picardie Pass Rénovation is a single point for homeowners for energy audits, recommendations for measures, financial solutions and post-installation checks.	Regional Board of the Public Service for Energy Efficiency in Hauts de France. (2013). France (p3). Link to website
Romania	National thermal rehabilitation programme	• Governmental renovation programme aimed at condominium associations that provides up to 80% of renovation costs.	National Thermal Rehabilitation Programme, Romania
Portugal	Energy Certification of Buildings	• The Portuguese EPC system managed by the Portuguese Energy Agency is one of Europe's frontrunners and has a database with more than 1.6 million EPCs. Plans exist to link EPCs with financial schemes (IFRRU 2020) and the one-stop-shop CasA+.	Portuguese energy certificate system. ADENE. Link to website
Poland/ Silesia	Poland Catching up 2 Regions	• The programme in the Silesia region includes financial instruments for increasing the energy efficiency of single-family buildings through the replacement of old heating installations, improving air quality and reducing smog.	Catching up 2 regions initiative. (2016). European Commission/World Bank
Ireland	Pro Energy Homes	• One-stop-shop initiative by private credit unions that provides low interest renovation loans that are supplemented with a 35% grant from the Sustainable Energy Authority of Ireland.	ProEnergy Homes. (2019). Credit Union Development Association

Scotland	Climate Action Plan Historic Environment	• Strategic approach to address needs of cultural heritage buildings to reduce their energy consumption, enhance their climate resilience and assure financial sustainability.	Historic Environment. (2019). Climate Action Plan 2020-25
Sweden	Carbon tax	• With a carbon price of approximately €110, the Swedish price is amongst the highest in Europe and has contributed to emission cuts in the built environment.	Government Offices of Sweden. (2020). Carbon Tax Sweden

5.6 Concluding assessment

The challenges of the strategic area "engaging transformation and phasing out inefficient buildings" have existed for decades. Most of the legislative and non-legislative policy instruments considered in this study try to address these challenges. However, the policy mix does not sufficiently incentivise measures that are not yet cost-effective, or to accelerate the renovation rate to the necessary level in order to reach the EU's long-term target of a decarbonised, highly efficient building stock.

Mandatory minimum requirements (Belgium, France, UK, Netherlands, USA), massively increased dedicated funding for deep energy renovation (Germany, Tirol), progressive EPCs (Portugal, Flanders) as well as building renovation passports (Flanders, Germany, France) to better inform homeowners show promising ways to accelerate deep energy renovations to meet long-term objectives. Other promising examples that could be transferred to other jurisdictions are initiatives to aggregate renovation projects (Netherlands, Baden-Württemberg) as well as integrated service providers (French regions, Ireland, Denmark). While there is no silver bullet, there is a growing diversity of better tailored and integrative approaches that can be used to trigger further policy development.

Assessment of impact per type of policy instrument

Mandatory instruments, especially minimum requirements to gradually phase out inefficient buildings, are considered as the most effective policy instruments regarding energy savings and greenhouse-gas emission savings. However, the introduction of a well-designed and therefore effective scheme faces several challenges (see below). Even though the design of existing cases could be optimised, they are very valuable frontrunner cases helping to understand good practice design elements. The ban of fossil-fuel heating is a first step to limit greenhouse-gas emissions, with the most practical examples including a ban on oil-fired boilers. Strategies and long-term planning including binding long-term targets are an important precondition for designing proper mandatory schemes to phase out inefficient buildings and prevent technological lock-ins.

Market-based instruments, in particular CO_2 prices, are considered important complements to widely used financing schemes. However, in order to effectively reduce carbon emissions in the building sector and boost the renovation market, the CO_2 price has to be considerably higher than in existing cases (estimations vary but are typically higher than those in place[93]).

While the most successful subsidy schemes helped to generate significant savings and have had some success in achieving deeper renovation, they are not yet able to accelerate the renovation activity significantly. Instruments for project aggregation and one-stop-shops are promising developments. So too are the new accelerator programmes for industrial renovation, which combine the insights of innovation theory and existing good practice subsidy programmes. However, support for production capacity (of e.g. prefabrication of facades on an industrial scale) is still missing in the existing programmes and could be the missing link to reach the full potential impact.

[93] See e.g. assumption in a report evaluating Germany's climate protection measures until 2030 www.bmwi.de/Redaktion/DE/Publikationen/Wirtschaft/klimagutachten.pdf?__blob=publicationFile&v=8

In order to increase synergies between different strategic areas and thereby reduce energy and CO_2 emissions, public policymaking can learn from private initiatives. This is especially true for private certification schemes and standards (e.g. DGNB, BREEAM, NOM keur, etc.).

All policy instruments will need to be accepted by a range of different actors. Information is therefore an important part of any enabling framework and has to be well tailored to specific building segments and target groups in order to be effective.

Assessment of ease of implementation per policy type

While mandatory instruments, especially minimum requirements to phase out inefficient buildings, are considered effective, their implementation faces some difficulties. Policymakers will have to gain political acceptance, provide financial support to minimise the burden on vulnerable groups, overcome subsidiarity issues, and ensure enforcement, monitoring and a smooth market uptake, amongst others. If designed well, they are very promising in terms of effectiveness, but need to be prepared well upfront, e.g. through no-regret measures like improving reliable EPC schemes and accessible EPC databases. The ban on fossil-fuel-based heating boilers is easier to implement, as it addresses only one element in the building energy system. Still, it is a highly political intervention and needs to match the political agenda. In some cases this depends on Member States' long-term climate strategies, or other goals such as reducing air pollution. To give an example, if green hydrogen is considered highly relevant, a phase-out of gas-based heating is unlikely.

Renovation strategies and planning are comparatively easy to implement. However, good strategies require proper research based on a robust data. Strategic planning on the individual building level, e.g. digital building logbooks or building renovation passports, which could also count as information or monitoring instruments, require a thorough design and testing phase. Existing cases are promising and can be considered a starting point to gradually improve the schemes to make them easily understandable, accessible and meaningful for homeowners, but also for public administrations as a data source. Differences in the EPC schemes across European Member States show the path-dependence of policy instruments and illustrate the difficulty of changing the scheme over time. Changes need to be stimulated at the European level (EPBD).

The existing European emissions trading scheme could be an entry point to introduce a CO_2 price to the EU building sector by extending it to heating fuels. However, there are doubts that politically accepted price levels could activate renovation activity.

Informative and voluntary instruments are easy to implement. However, their effectiveness unfolds only if combined with other instruments, such as financing schemes and/or mandatory requirements. The implementation of financial support is highly dependent on the availability of funding. Grants depending on the annual public budget are more difficult to set up and to sustain. Therefore, it is helpful to establish budget-independent income streams. Apart from existing European finance instruments, revenues from the EU emissions trading scheme could provide another income stream for Member States.

Financing renovation – Factsheet

Author: Andrea Real Ruiz, Laura Pérez del Olmo, Pedro Luis Espejo

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6.1 Introduction

This factsheet provides an overview of how different policy instruments and selected private initiatives can help to achieve European objectives and effectively address key EU challenges in the strategic area of **financing renovation**. The findings draw upon a policy screening for 15 EU Member States, 3 non-EU countries and 5 European regions covering broadly the climatic zones of the EU. In addition, the factsheet draws on additional information provided by external experts as well as on the long-standing expertise of the authors, meaning policy examples going beyond the researched country and region cases are occasionally added. The concluding assessment draws on the findings and detailed analysis of the good practice cases as well as on the in-house expertise of the partners.

6.2 Financing renovation

Availability and accessibility of financing and appropriate financing tools are essential to increase the rate and depth of building renovations. Public finance alone cannot support this effort and must be used to leverage additional private investment. Innovative financing schemes and business models are emerging to maximise the effectiveness of funds, as well as to target specific market failures for renovations or more vulnerable groups of citizens. Three key challenges to unlocking an increasing amount of private resources to finance building renovations have been identified:

1) Unlocking financing for renovations for end-users: to increase renovation rates, there is a clear need to create and proactively deliver mechanisms and support programmes with the financing capacity to stimulate investments, including targeting buildings occupied by the most vulnerable consumers. First, to achieve lower cost financing and better access for tenants and occupants, the creditworthiness and security of repayments for energy efficiency retrofits must be improved. Building occupants are the most engaged stakeholders; however, they are also the least likely to engage in building renovation unless they are also the homeowner. Second, many end-users lack available funds, which prevents them from implementing the desired measures. The involvement of banks and energy suppliers in the supply of energy efficiency retrofit solutions to their individual and commercial customers can lead them to offer more profitable products to those same customers. Third, investments from the public sector are also necessary. Member States should implement and design effective mechanisms that allow all users to execute renovations at reasonable cost, taking into consideration the difficulties they may face (e.g. lack of available funds, high upfront costs, etc.).

2) Financing building renovations in the presence of market failures: adequate financial instruments to overcome market failures are of central importance to achieve and sustain higher deep renovation rates. Market failures are understood as a range of problems that tend to delay the transformation of the building stock and the tapping of cost-effective energy savings potential. These may include, for example, lack of understanding of energy use in buildings and potential savings resulting from renovations; lack of attractive financial products; high upfront costs of renovation and long payback periods; low energy prices negatively affecting payback of energy savings measures; limited information and data availability about the building stock; limited uptake of efficient and smart technologies; split incentives. Adequate financial instruments to overcome market failures, a sufficient workforce with the right skills, and affordability for all citizens are of central importance if the Union is to achieve and sustain higher renovation rates.

3) Mobilising and de-risking energy efficiency investment: lack of evidence on the performance of energy efficiency investments in buildings makes financial risk harder to assess and mobilisation of both public and private investments more difficult. Suitable platforms for dialogue and exchange of good practice, promoting the provision of reliable, comparable and verifiable information, are needed in order to de-risk energy efficiency investments and engage stakeholders. There is also a lack of standard financial approaches for building renovations, such as agreed protocols and benchmarking rules for private capital investment and 'ready to use' financial products that would facilitate de-risking of investments. Additionally, risks related to energy efficiency investments can fall under five categories: economic and financial; behavioural and operational; measurement and verification; contextual and technological; and regulatory. The factors that determine the categorisation of risks/barriers and how they can be solved range from market-specific (e.g. lack of appropriate financing vehicles or debt instruments, regulatory risks, volatile energy prices), investor-specific (e.g. risk aversion, behavioural bias, perceived lack of collateral), to project-specific barriers (e.g. high initial costs, long payback periods, uncertainty of technology).

6.3 Provisions to address key challenges

This section gives an overview of the policies considered to be most successful at tackling key challenges in the area of financing renovation. To operationalise the challenges and allow for quantitative estimations on selected aspects, the country screening looked for provisions including de-risking tools, schemes to alleviate energy poverty, mandatory support take-up, standard financial approaches and innovative financing schemes.

The figure provides an overview of the policy screening. Since countries vary in size, the number of provisions does not necessarily reflect the effectiveness of the policy mix. While the number of provisions found may give an indication of the breadth and diversity of approaches, it should not be taken as the sole indicator for how effective the provisions are for tackling key challenges. One well-designed policy instruments may be more effective than a multitude of less adequate instruments. Therefore, an additional qualitative discussion as well as insights from the good practice analysis are provided in the remaining parts of the paper.

Financing renovation is essential for the building sector as it is the key pillar of Member States' long-term renovation strategies. The policies identified (65.5% legislative and 34.5% non-legislative) associated with mobilisation of both public and private investments in order to overcome the identified key challenges.

Our research finds that the most common practice to address the key challenges is through standard financial approaches, which have been implemented across research countries (except Greece and Lithuania) in a multitude of ways: via public and private loans, tax rebates, subsidies or grants. This type of measure promotes renovation by providing funding to support energy efficiency investments and enabling more effective use of public funding and better targeting of subsidies towards vulnerable consumers or specific market failures. Such measures tend to be implemented in national and regional legislation, as in

Germany (e.g. KfW Energy Efficiency Programme[94] at national level and Bavarian modernisation programme: State funding for the renovation of rented apartments and care places in Bavaria[95] at regional) and Spain (e.g. Measures to support energy efficiency in central government[96] at national level and 2014-2020 ERDF Operational Programme for Extremadura[97] at regional level). However, other jurisdictions have non-legislative support programmes (e.g. California's Green Retrofit Program for Multifamily Housing[98]).

Innovative financial schemes are more and more common among Member States and represent a way to access attractive financing solutions and benefit from innovative energy services in the form of e.g. energy performance contracting[99], on-tax and on-bill financing, or mortgages for energy efficiency. Member States have been taking important actions to promote these services, especially in the public sector. Relevant approaches include, among others, Spain's measures to promote energy services[100], Italy's Ecobonus[101] which deducts up to 110% of the costs incurred in the tax declaration process or the Netherlands' Building-related Financing[102] and the USA's Energy Efficient Mortgages[103], which link loans for energy renovations to the respective building instead of the building owner.

On the other hand, the lack of evidence on the performance of energy efficiency investments in buildings makes the benefits and the financial risk harder to assess. In this context, de-risking tools refer to those measures that provide reliable, comparable and verifiable information, imperative to de-risk energy efficiency investments for building renovation. This was identified by the "Smart Finance for Smart Buildings" investment initiative as one of the main issues to address to incentivise the uptake of energy renovations. In this regard, the picture among Member States is not completely clear; the approaches taken by countries vary widely. Some recurring measures include public financing (e.g. the Greek Saving at Home II Program[104]), databases compiling relevant

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[94] *IKU – Energieeffizient Bauen und Sanieren (220, 219)*. Kfw.de. (2020). Retrieved 12 August 2020, from https://www.kfw.de/inlandsfoerderung/%C3%96ffentliche-Einrichtungen/Kommunale-Unternehmen/Kommunale-Geb%C3%A4ude/Energieeffizient-Sanieren-kommunale-Unternehmen-(220-219)/.

[95] *Bayerisches Modernisierungsprogramm für Wohnungsgesellschaften | BayernLabo*. Bayernlabo.de. (2020). Retrieved 12 August 2020, from https://bayernlabo.de/mietwohnraumfoerderung/bayerisches-modernisierungsprogramm/?L=0.

[96] GOVERNMENT OF SPAIN MINISTRY OF ENERGY, TOURISM AND DIGITAL AGENDA. (2017). *2017-2020 NATIONAL ENERGY EFFICIENCY ACTION PLAN*. Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/es_neeap_2017_en.pdf

[97] GOVERNMENT OF SPAIN MINISTRY OF ENERGY, TOURISM AND DIGITAL AGENDA. (2017). *2017-2020 NATIONAL ENERGY EFFICIENCY ACTION PLAN*. Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/es_neeap_2017_en.pdf

[98] American Recovery and Reinvestment Act of 2009, Public Law 111-5, Title XII. "Assisted Housing Stability and Energy and Green Retrofit Investments" under "Housing Programs".

[99] https://eur-lex.europa.eu/resource.html?uri=cellar:fa6ea15b-b7b0-11e6-9e3c-01aa75ed71a1.0001.02/DOC_2&format=PDF

[100] Plan MOVALT Vehículos | IDAE. (2020). Retrieved 1 July 2020, from https://www.idae.es/ayudas-y-financiacion/para-movilidad-y-vehiculos/convocatorias-cerradas/plan-movalt-vehiculos

[101] PAE. (2017). *Italian Energy Efficiency Action Plan*. Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/it_neeap_2017_en.pdf

[102] Netherlands Enterprise Agency. (2020). *Long-Term Renovation Strategy, En Route to a low-CO2 Built Environment*. Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/nl_2020_ltrs_en.pdf

[103] *Energy Efficient Mortgages*. Energystar.gov. (2020). Retrieved 12 August 2020, from https://www.energystar.gov/newhomes/mortgage_lending_programs/energy_efficient_mortgages.

[104] ΕΛΛΗΝΙΚΗ ΔΗΜΟΚΡΑΤΙΑ ΥΠΟΥΡΓΕΙΟ ΠΕΡΙΒΑΛΛΟΝΤΟΣ ΚΑΙ ΕΝΕΡΓΕΙΑΣ ΕΠΙΤΕΛΙΚΗ ΔΟΜΗ ΕΣΠΑ ΥΠΕΝ ΤΟΜΕΑ ΕΝΕΡΓΕΙΑΣ ΟΔΗΓΟΣ. (2020). *ΟΔΗΓΟΣ ΕΦΑΡΜΟΓΗΣ ΠΡΟΓΡΑΜΜΑΤΟΣ «ΕΞΟΙΚΟΝΟΜΗΣΗ ΚΑΤ' ΟΙΚΟΝ ΙΙ»*. Αθήνα. Retrieved from https://exoikonomisi-b.ypen.gr/documents/10182/3568822/2%CE%97+%CE%A4%CE%A1%CE%9F%CE%A0+%CE%9F%CE%94+%CE%95%CE%9E%CE%9F%CE%99%CE%9A_II_2019+%CE%92+final.pdf/07cccb97-535b-44ad-a2ea-c89c9ed912d8

information about legislation and available funding (e.g. Portugal's Energy Observatory[105]) or more informative measures looking to portray the benefits of building renovations (e.g. Andalusia's diffusion of energy improvement in sectors of the Andalusian economy[106]). All these have the aim of showcasing the benefits of energy renovations and incentivising the mobilisation of resources to implement such measures.

Finally, awareness of energy poverty is growing rapidly across Member States. In fact, 80% of the researched countries present schemes to alleviate energy poverty and to tackle the renovation of the worst-performing buildings, thus reducing the household energy bills. Article 2a of the Energy Performance of Buildings Directive[107] (EPBD) requires Member States to establish specific measures and financing instruments in their renovation strategies to decrease energy demand and contribute to the alleviation of energy poverty. Approaches taken by researched countries include France's Social Housing Eco-loan[108] for the energy renovation of social housing or the USA's High Energy Cost Grants[109], which helps energy providers to lower the energy costs for families and individuals that live in areas with extremely high per-household energy costs.

[105] (Observatório da Energia,2020). Retrieved 1 July 2020, from https://www.observatoriodaenergia.pt/pt/politicas-publicas

[106] Junta de Andalucía. (2020). *Plan de Acción 2018-2020, Estrategia Energética de Andalucía 2020* [Ebook]. Retrieved from https://www.agenciaandaluzadelaenergia.es/sites/default/files/documentos/plan_de_accion_2018-2020.pdf

[107] Energy performance of buildings directive - European Commission. (2020). Retrieved 1 July 2020, from https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en

[108] Rénovation Energétique des Bâtiments. (2018). *Stratégie à long terme de la France pour mobiliser les investissements dans la rénovation du parc national de bâtiments à usage résidentiel et commercial, public et privé*. Retrieved from https://www.cohesion-territoires.gouv.fr/sites/default/files/2020-02/200210_Strat%C3%A9gie_de_r%C3%A9novation_2020_vf.pdf

[109] 7 U.S. Code Subchapter I - RURAL ELECTRIFICATION. (2020). Retrieved 1 July 2020, from https://www.law.cornell.edu/uscode/text/7/chapter-31/subchapter-I

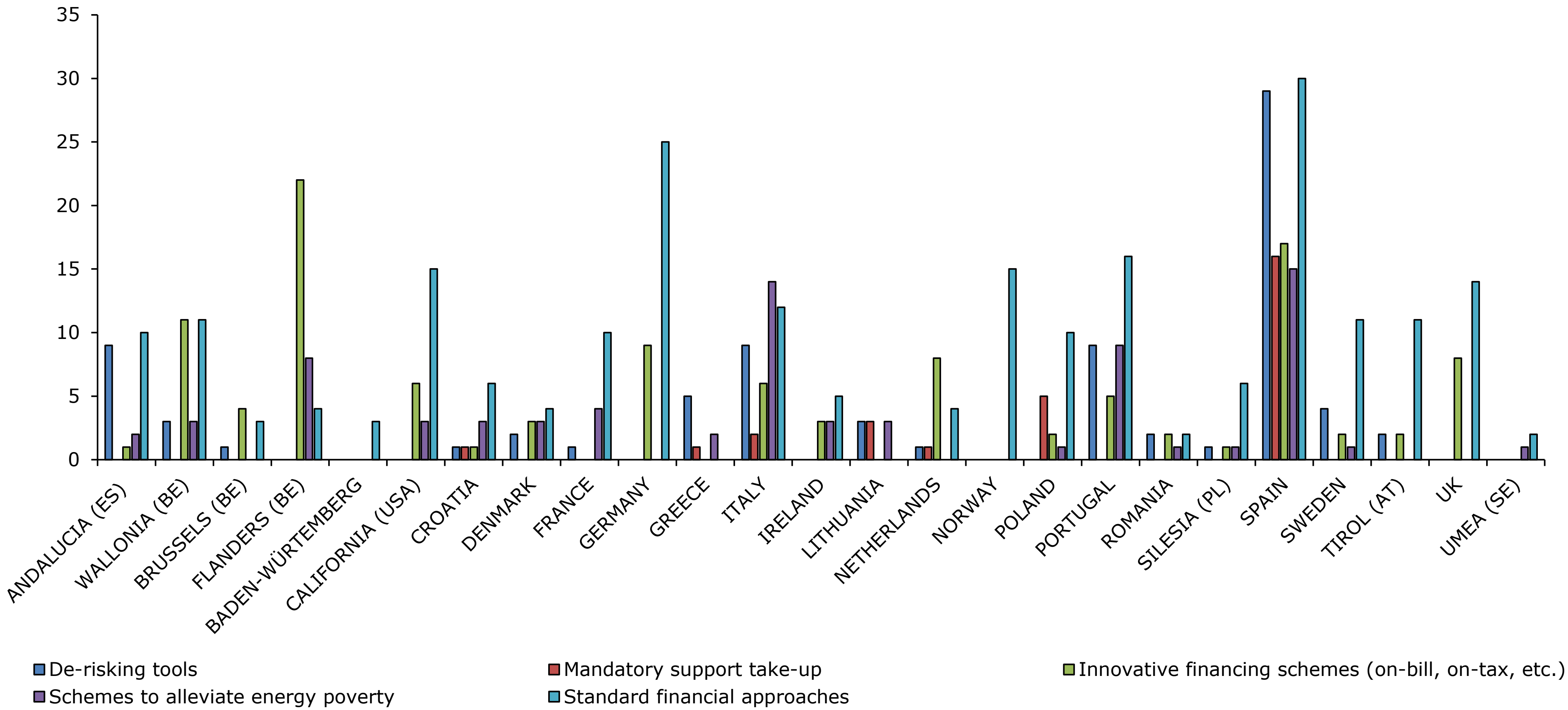

Figure 5 - Key aspects of financing renovation per country

6.4 Effectiveness of the policy landscape to address key challenges – overview and description

This section presents an assessment of the overall policy landscape that a previous country screening identified as relevant for the covered countries and regions. The assessment takes into account the diversity of instruments (regulation, pricing, support, information etc.), whether there are particularly interesting and innovative instruments, and whether the instruments identified together seem adequate to address the given challenges. The overview tables are followed by a discussion of policy instruments.

The given classification in Table 8 and Table 9 should be interpreted as follows:

	Good policy landscape with at least one innovative instrument targeting financing renovation
	Adequate policy landscape with instruments that could in the future better integrate financing in building renovation policies
	Inadequate policy landscape, with no instruments identified in relation to the given challenges
	Not conclusive

Table 8 – Legislative policies

	Financing renovation – legislative policies		
	KEY CHALLENGES		
	Unlocking financing renovation for end-users	Financing renovations in the presence of market failures	Mobilising and de-risking EE investments
Flanders			
Wallonia			
Brussels			
Croatia			
Denmark			
France			
Germany			
Greece			
Ireland			
Italy			
Lithuania			
Netherlands			
Poland			
Portugal			
Romania			
Spain			
Sweden			
UK			
Norway			
USA			
Andalusia			
Tirol			

Baden-Württemberg			
Silesia			
Umea			

Table 9 – Non-legislative policies

	Financing renovation – non-legislative policies		
	KEY CHALLENGES		
	Unlocking financing renovation for end-users	Financing renovations in the presence of market failures	Mobilising and de-risking EE investments
Flanders			
Wallonia			
Brussels			
Croatia			
Denmark			
France			
Germany			
Greece			
Ireland			
Italy			
Lithuania			
Netherlands			
Poland			
Portugal			
Romania			
Spain			
Sweden			
UK			
Norway			
USA			
Andalusia			
Tirol			
Baden-Württemberg			
Silesia			
Umea			

As mentioned earlier, the policies identified in the researched countries regarding financing renovation tend to be legislative. Because of this, when conducting an analysis of the effectiveness of the policy landscape and the measures implemented, their effect on the key challenges will be analysed in tandem.

1) Unlocking financing for renovation for end-users

To increase renovation rates, there is a clear need to create mechanisms and support programmes with the financing capacity to stimulate investments, including targeting buildings occupied by the most vulnerable consumers. Those mechanisms must come from the effort of relevant stakeholders in the field: national, regional and local governments, financial institutions and service providers.

Because the spectrum of policies that can serve to "fix" this key challenge is so vast, the approaches taken by countries are quite varied, some of which are highlighted below:

In Croatia, a programme has been created to combat energy poverty via public financing. The specific objective of the measure is the establishment of a system that would allow vulnerable energy buyers to improve energy efficiency at household level while improving housing conditions. The programme establishes a list of available measures and rate of co-financing for individual measures.

In the United States, the Green Retrofit Program for Multifamily Housing[110], handled by the Department of Housing and Urban Development, gives loans and grants to eligible property owners to make energy and green retrofit investments in the property, and to ensure the maintenance and preservation of the property, the continued operation and maintenance of energy efficiency technologies, and the timely expenditure of funds. In Portland, to finance the Clean Energy Community Benefits Fund[111], large retailers pay a surcharge of 1% on gross revenues from retail sales. The capital raised is distributed among several programmes, including clean energy ones focused on renewable energy and energy efficiency projects, with an emphasis on those that benefit low-income individuals and that broaden access to energy efficiency and clean renewable energy infrastructure to low-income communities and communities of colour.

The Housing Bank[112] in Norway grants loans to individuals which can be used to improve the environmental performance and accessibility of new and/or existing buildings. In Poland, the government has approved a tax relief[113] for thermo-modernized single-family residential buildings.

Portugal uses its social tariff[114], managed by the Directorate-General for Energy and Geology, as social support for end-consumers to have a discount on the tariff for low voltage electricity and low-pressure natural gas networks.

In Andalusia, a grant[115] has been created for the energy rehabilitation of residential buildings. Incentives are provided for energy saving measures, energy efficiency improvements, the use of renewable energies and reduced carbon dioxide emissions in existing buildings belonging to the public administrations of Andalusia, for use as housing for low-income families or people with special needs.

In Lithuania, the renovation/modernisation of multiapartment buildings[116] aims to renovate by the end of 2030 around 5,000 multi-apartment buildings (500 multi-apartment buildings each year) to class C and save 40% of the building's energy

[110] HUD Archives: Green Retrofit Program for Multifamily Housing. (2020). Retrieved 1 July 2020, from https://archives.hud.gov/recovery/programs/green.cfm

[111] Chapter 7.07 Portland Clean Energy Community Benefits | The City of Portland, Oregon. (2020). Retrieved 1 July 2020, from https://www.portlandoregon.gov/citycode/78811

[112] HAKJ, m. (2020). Lån fra Husbanken for privatpersoner - Husbanken. Retrieved 1 July 2020, from https://husbanken.no/person/lan-fra-husbanken/?redirect=/privat/lan-fra-husbanken/

[113] Kancelaria Sejmu. USTAWA z dnia 9 listopada 2018 r o zmianie ustawy o podatku dochodowym od osób fizycznych oraz ustawy o zryczałtowanym podatku dochodowym od niektórych przychodów osiąganych przez osoby fizyczne (2018).

[114] Energy Social Tariff – Policies - IEA. (2020). Retrieved 1 July 2020, from https://www.iea.org/policies/2619-energy-social-tariff?country=Portugal&qs=portug

[115] Junta de Andalucía. (2020). *Plan de Acción 2018-2020, Estrategia Energética de Andalucía 2020* [Ebook]. Retrieved from https://www.agenciaandaluzadelaenergia.es/sites/default/files/documentos/plan_de_accion_2018-2020.pdf

[116] NECAP Lithuania. (220). *National Climate and Energy Action Plan of the Republic of Lithuania for 2021-2030.* Accessible at: https://ec.europa.eu/energy/sites/ener/files/documents/lt_final_necp_main_en.pdf

consumption, seeking to reduce heating costs for consumers, improve their living conditions and save a total of 5.5 TWh of energy.

Lastly, in France, the Coup de pouce (Helping Hand)[117] scheme for energy savings enables all households to benefit from a one-off grant to assist them in funding certain energy renovation works, helping all individuals to get out of fossil fuels, to insulate their homes and thus significantly reduce their heating bills. It is financed within the framework of the energy savings certificates, a generally available funding stream in France. Another relevant subsidy available is the French tax-free zero-rated eco-loan scheme[118], which allows landlords to get a loan to finance energy refurbishment works (insulation, heating or water heating using renewable energies) for their main residence.

2) Financing renovations in the presence of market failures

Adequate financial instruments to overcome market failures are of central importance to achieve and sustain higher deep renovation rates. Some of the most relevant market failures identified include the split-incentive dilemma and conflicts of interest, limited financing/insufficient budgets, lack of funds for energy efficiency service providers, and the difficulties in conveying energy and non-energy benefits of retrofits. The approaches taken by countries to diminish the extent of such market failures are very diverse but are largely focused on private and public financing (whether via loans and grants or tax rebates) and the promotion of energy services. This key challenge is the one that researched countries have taken the most successful actions to tackle, as shown in the tables above.

Ireland has come up with a few tax rebates aiming at involving, among others, tenants and landlords. The Home Renovation Incentive[119] is a tax credit scheme that allows homeowners, landlords and local authority tenants to claim income tax relief for repairs, renovation or upgrades of owned or rented buildings. The scheme enables eligible candidates to claim a tax credit of 13.5% of the total costs of building repairs, renovations or energy efficiency improvements. The Living City Initiative[120] offers tax relief for renovation works and building upgrades in special regeneration areas (old/historic town centres).

In Spain, an action plan for training energy service companies implemented several measures to promote[121] and drive the market for efficient and sustainable energy services as part of the cooperation agreement between the Institute for the Diversification of Energy and Energy Savings (IDAE) and the School for Industrial Organization. A similar measure has been implemented in Romania, with the creation of an ESCO [energy service

[117] Ministere de la transition ecologique (2018) Long-term strategy of France for mobilising investment in the renovation of the national stock of residential and commercial buildings, both public and private. https://ec.europa.eu/energy/sites/ener/files/documents/fr_ltrs_2020_en.pdf

[118] Qu'est-ce que l'éco-prêt à taux zéro ?. Economie.gouv.fr. (2020). Retrieved 28 August 2020, from https://www.economie.gouv.fr/cedef/eco-pret-a-taux-zero.

[119] HRI for homeowners and landlords. (2020). Retrieved 1 July 2020, from https://www.revenue.ie/en/property/home-renovation-incentive/hri-for-homeowners-and-landlords/index.aspx

[120] Living City Initiative (LCI) definitions. (2020). Retrieved 1 July 2020, from https://www.revenue.ie/en/property/living-city-initiative/lci-definitions.aspx

[121] *BORRADOR DEL PLAN NACIONAL INTEGRADO DE ENERGÍA Y CLIMA 2021-2030*. (2020). Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/spain_draftnecp.pdf

company] Working Group[122] which promotes dialogue between representatives of the national government and international institutions and NGOs for the development of a standardised energy performance contracting model to support local public authorities in carrying out building efficiency improvements.

The On-Bill Financing[123] service offered by the Burlington Electric Department in California provides business customers with the option to finance electric efficiency improvements on their electric bill.

3) Mobilising and de-risking energy efficiency investments

Lack of evidence on the performance of energy efficiency investments in buildings makes financial risk harder to assess and mobilisation of both public and private investments more difficult. The Smart Buildings Initiative stresses the importance of the need to de-risk energy efficiency investments in buildings by giving investors and private financiers a better understanding of the risks and benefits of energy efficiency.

In general, this key challenge has been the least tackled by analysed countries, though there are some relevant schemes in Member States. These include energy efficient mortgages like the Green Mortgage programme[124] in Romania. Together with the Raiffeisen Bank, the programme offers discounted mortgage pricing to suitably qualified, prospective homebuyers for buildings certified by Romanian Green Building Council within the Green Homes certification scheme.

Crowdfunding has also gained some ground in recent years by offering support to sustainable energy projects through debt financing options, even though they currently account only for a very small share of the sector. For instance, Bettervest in Germany is a crowdfunding platform which has started supporting energy efficiency projects.

Energy efficiency insurance, an innovative product which aims to shield from under-achievement and increase trust and awareness of energy efficiency projects, is currently used in Wallonia[125] through an insurance mechanism for group loans.

Other vehicles to drive more investments are specialised energy efficiency funds, like the Spanish National Energy Efficiency Fund[126], which aims to activate and integrate financial entities to raise investment for energy efficiency and renewable energies with the support of all public and private agents and regional administrations.

Information-based provisions include Portugal's Energy Observatory[127], which aims to provide reliable, comparable and verifiable information, and measures looking to portray the benefits of building renovations (e.g. Andalusia's diffusion of energy improvement in

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[122] ANRE, AUTORITATEA NAȚIONALĂ DE REGLEMENTARE ÎN DOMENIUL ENERGIEI. (2019). *R A P O R T de monitorizare a implementării Planului Național de Acțiune în domeniul Eficienței Energetice (PNAEE IV) – 2018*. Retrieved from https://www.anre.ro/ro/eficienta-energetica/rapoarte/rapoarte-de-monitorizare-a-implementarii-planului-national-de-actiune-in-domeniul-eficientei-energetice-pnaee

[123] On-Bill Financing | Burlington Electric Department. (2020). Retrieved 1 July 2020, from https://www.burlingtonelectric.com/on-bill-financing

[124] Niculescu, I. (2020). *Romania Green Building Council - Green Mortgage*. Rogbc.org. Retrieved 27 August 2020, from http://www.rogbc.org/en/projects/green-mortgage.

[125] LTRS-W p. 145. https://ec.europa.eu/energy/sites/ener/files/documents/be_wallonie_building_renov_2017_fr.pdf

[126] Draft of the integrated national energy and climate plan 2021-2030. (2019) https://ec.europa.eu/energy/sites/ener/files/documents/es_final_necp_main_en.pdf

[127] LEGISLAÇÃO DO SETOR ENERGÉTICO PESQUISA DE LEGISLAÇÃO. (2020). Retrieved 1 July 2020, from https://www.observatoriodaenergia.pt/pt/politicas-publicas

sectors of the Andalusian economy[128]). In France, the Tinergy[129] platform simplifies, secures and optimises personal home energy renovation projects by offering a support service upstream and downstream of the work. It also supports local professionals and facilitates their access to the energy renovation market.

[128] Junta de Andalucía. (2020). *Plan de Acción 2018-2020, Estrategia Energética de Andalucía 2020* [Ebook]. Retrieved from https://www.agenciaandaluzadelaenergia.es/sites/default/files/documentos/plan_de_accion_2018-2020.pdf

[129] ADEME. (2016). *RÉNOVATION ÉNERGÉTIQUE DE L'HABITAT, 15 INITIATIVES DE TERRITOIR E S*. Retrieved from https://www.ademe.fr/sites/default/files/assets/documents/renovation-energetique-habitat-initiatives-territoires-8890.pdf

6.5 Highlighting good practice examples

Based on the results of the previous research as well as on expert knowledge, this section portrays selected good practice examples. Each example fulfills one or several of the following selection criteria: innovation (new mechanism, triggering innovation, scaling up innovation), impact (on EU objectives, energy savings, CO_2 emission reduction, potential renovation impact), ease of implementation (including transferability, scalability, transaction and administrative costs, budget (in-)dependency, compatibility with existing legislative/policy framework) and coverage of diverse jurisdiction and climatic zones.

Country	Policy	Brief description	Source
Germany	KfW Energy Efficiency Programme - Energy-efficient renovation investment subsidy	• This programme serves to promote comprehensive refurbishment into “KfW efficiency houses” or individual measures to improve energy efficiency. As well as repayment bonuses dependent on the primary energy consumption of the efficiency house, a special promotion is possible if construction is supervised by an external technical expert. o Through the loan, applicants can receive an investment subsidy that depends on the energy standard achieved.	KfW
USA	Property Assessed Clean Energy (PACE)	• Property Assessed Clean Energy (PACE) is a way to finance a wide range of energy and water efficiency, renewable energy, and hazard mitigation improvements permanently attached to residential (R-PACE) and commercial properties (C-PACE). o Established by state statutes and enabled by local governments, PACE financing is structured as an assessment to the property and not the property owner. PACE provides 100% of the cost of qualified structural improvements, which the property owner repays annually or semi-annually through a special assessment added to the property tax bill. o The average repay period is typically over 10 to 20 years through property assessments, which are secured by the property itself and paid as an addition to the owner’s property tax bills.	PACE
France	Denormandie Law	• The Denormandie Law aims to renovate dilapidated housing in some French cities through an advantageous tax exemption programme for investors • Renovation work should: o Improve the energy performance of housing by at least 30% (20% in collective housing) o Represent two types of work out of a choice of five: roof insulation, change of boiler, wall insulation, window insulation, change in hot water production	LTRS P62

		• The Denormandie Law allows tax exemption of up to 21% of the price of the property purchased if it is rented for 12 years. This will act as an incentive for the renovation of rented properties, tackling the split-incentive dilemma.	
Poland	Stop smog	• The programme finances the replacement or elimination of heat sources and thermo-modernisation in residential buildings for those in energy poverty. Applicants are municipalities, which obtain up to 70% co-financing of investment costs from the state budget. • The scope of the project includes: ○ Replacement or elimination of high-carbon heat sources for low-carbon ones ○ Thermo-modernisation of single-family residential buildings ○ Connection to the heating or gas network. • Implementing financial measures that ensure those under the energy poverty line are not left behind is vital for a fair energy transition.	Stop smog
Italy	Ecobonus/ Superbonus	• Tax credit equal to up to 110% of the energy renovation investment that can be recovered in five years by either the final user, the construction company or a financial intermediary. • In general, deductions are recognised for: ○ Reduced energy requirements for heating ○ Thermal improvement of the building (insulation/floors/windows, including fixtures) ○ Installation of solar panels ○ Replacement of winter air-conditioning systems. • It applies to residential, non-residential and mixed buildings. ○ The Superbonus can set an example in Europe as a useful tool to promote a green recovery in the building sector, by setting incentives for households and companies.	Gazzetta Ufficiale
Croatia	Methods of making energy renovation investments more attractive to banks and private investors	• Establishment of a national revolving fund by means of redeploying resources from European structural and investment funds, which allows energy service providers to access to a long-term funding source at more favourable market conditions. Banks can also place resources through the fund. ○ By introducing special guarantee instruments, risk for private investor funds is reduced; ○ Subsidising the interest rates on commercial loans enables commercial banks to finance building energy renovation. ○ Developing a standard energy performance contract and standardised methods for measuring and verifying energy savings will enhance the trust of users and financial institutions in the ESCO model.	LTRS

		• Lack of evidence on the performance of energy efficiency investments makes the benefits and the financial risk harder to assess. This measure can help reduce the perceived risks associated with building retrofits and mobilise funds	
Netherlands	Tenants' right of initiative for deep renovation	• Consideration to change the Civil Code to enable tenants to obligate landlords to make certain improvements ○ Under current Civil Code the lessor is obliged to make certain improvements at their own expense at the request of the tenant, provided that the tenant accepts a rent increase in reasonable proportion to these costs (e.g. insulating the external partitioning structures). ○ Government is currently assessing whether rules should be amended to allow the deep renovation of the housing stock and whether the standards and target values can play a role in a possible adjustment.	LTRS P38-39

6.6 Concluding assessment

Assessment of impact per type of policy instrument

Financing is a key strategic area in achieving the goals set out by Member States in their renovation strategies. Three key challenges have been defined:

- Unlocking financing for renovations for end-users
- Financing building renovations in the presence of market failures
- Mobilising sustainable investments and de-risking energy efficiency investment.

Several barriers hinder the increase in financing for renovation. Split incentives and inadequate information about costs and benefits are major obstacles, while high upfront costs, lack of access to finance and scarcity of private capital emphasise the need for more policy and market action.[130]

Because grants are available across most analysed countries, and can cover up to 100% of the costs of renovation activities, their impact can be considerable in terms of deeper renovations. They directly fill an immediate financial gap and thus enable a temporary shift in the market. However, they typically rely on limited resources and can, therefore, neither offer a sustainable solution nor support mass-market uptake programmes.

One of the issues identified with this type of instrument is that instead of targeting a specific typology or neighbourhoods with, for example, high levels of energy poverty, projects are often chosen based on the readiness of the recipient (municipalities, banks, etc.) and the simplicity of the project. These unambitious aims can have a negative effect on the depth of renovation, since setting insufficient energy performance targets may create a lock-in effect that prevents future renovations.[131] Also, allocating public grants may not trigger the private investment needed to meet targets.

Debt financing in the form of loans can be a more sustainable means of up-scaling energy efficiency investments as they can provide liquidity and direct access to capital. Loans can be more relevant for energy efficiency measures attached to high upfront costs, especially in deep renovation projects which comprise a package of multiple intervention measures.[132]

Government programmes can partly or fully finance energy efficiency retrofit transactions (eg. KfW and Green Deal), and offer subsidised interest rates and placement fees to banks or utility distribution networks for sale and transaction processing services. Low interest rates are a common feature of most of national loan schemes in the EU targeting energy efficiency investments.

Private debt financial products designed specifically for energy renovations in buildings are currently not fully developed, as financial institutions are often unfamiliar with these investments and thus perceive energy efficiency loans as high-risk. High transaction costs for relatively small projects and failure to offer financing for terms long enough to support deeper measures are additional factors hindering market uptake.

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[130] Bertoldi, P. and Economidou, M. (2014). *Financing Building Energy Renovations*
[131] BPIE (2017). *Financing the Future of Buildings in Central, Eastern And South-East Europe*.
[132] JRC (2019). *Accelerating Energy Renovation Investments In Buildings*

Taking the example of Germany and KfW's Energy Efficiency Programme, the measures supported by the programme are helping to reduce carbon emissions by almost 9 million tonnes per year. It has also triggered investments of over €260 billion in building measures and secured an average of 320,000 jobs per year in the building industry and regional trades. Every second newly built home in Germany is currently supported by funds from the "Energy-efficient Construction" programme and close to 290,000 homes received an energy-efficient makeover with the help of KfW in 2016. However, while deeper renovations are triggered with the programme, its effect on the renovation rate is minor.

The creation of innovative financial instruments, such as on-bill schemes, and more dedicated and effective use of funding streams is essential to renovate the building stock. The main objective of these mechanisms is to move from grants towards instruments that leverage private sector resources.

In the current context of available capacity in the economy and stress on public budgets, energy savings projects are a particularly attractive option to increase economic activity, as several structural barriers are holding back otherwise profitable investments.

Experience shows that while on-bill schemes can successfully overcome important barriers such as upfront cost and split incentives, there are still issues that need to be addressed. These include the need to modify billing systems, the role of utilities as financial institutions, risks of no payment, handling transfer of property, diversifying sources of capital, etc.

On-tax financing mechanisms can reduce first-cost barriers by linking repayment of energy efficiency investments to taxes, allowing customers to pay back part or all of the costs over time. The funds can originate from utilities, the state or third parties, e.g. commercial banks.

In terms of impact, PACE in California, for example, saved 29.754 billion kWh between 2009 and 2019. This translates into CO_2 emission savings of up to 7.44 billion tonnes in the same period. Furthermore attaching these mechanisms to the property itself (as opposed to its occupant) reduces their risk and should remove them from the relatively high-cost world of consumer finance (bringing them more appropriately into the lower-cost world of asset finance).

Energy efficiency obligations, required under the EU Energy Efficiency Directive, are instruments enacted by governments in order to stimulate energy efficiency investments through obligations placed on energy companies. Under an energy efficiency obligation scheme, energy distributors or retail energy sales companies are required to achieve a certain amount of energy savings in a pre-defined time. Member States typically mandate energy companies to achieve yearly energy savings of 1.5% of annual sales to final consumers. Once implemented, energy efficiency obligations have the advantage of boosting the market for energy efficiency investments by stimulating the development of new business models such as ESCOs and provide an additional income stream for renovation programmes. In addition, if designed properly, they give a fairly good estimation of the actual savings achieved through the programme.

Finally, guarantees can provide a valuable solution in cases where financial intermediaries (lenders) are reluctant to fund energy efficiency projects due to high perceived risks. There are different types of guarantee mechanisms, such as loan guarantees and risk sharing arrangements. By providing financial guarantees to enhance project creditworthiness, guaranteed loans can boost energy efficiency while at the same time reducing tax deductible interest payments, creating more taxable income for governments.[133]

Assessment of ease of implementation per policy type

The level of transferability of grants across countries is considered high, since they are easy to manage, require less administrative preparation and maintenance, and don't need legislative changes to implement. In fact, most of the countries analysed already have grants in place for renovation.

Loans can be easily implemented by banking institutions, reducing long bureaucratic processes often linked with government grant schemes. However, the decision falls mainly on financial institutions that are usually private organisations. In addition, financial institutions traditionally perceive a higher risk in energy efficiency investments which may hinder their deployment.

Energy performance/energy service contracts, which are mostly offered by ESCOs, are considered risky due mainly to the temporary link of the instrument with the life of the ESCO, which can be significantly affected by economic or political instability. Therefore, the level of transferability will be higher in countries with economic and political stability.

On-bill schemes and on tax-programmes exist in several states, regions and local governments. Programmes vary across several dimensions including the level of organisation (state-wide vs. local programmes), financing structures, and eligible measures. These programmes are typically enabled through state legislation and authorised at the local government level. Municipalities may administer residential programmes directly, or through public-private partnerships with one or more providers. The degree of transferability across countries is considered moderate, since the feasibility is dependent on internal regulation in each country. The role of municipalities or local governments as a capital provider might cause conflicts in certain countries.

A number of EU Member States have already introduced suppliers' obligations to encourage energy efficiency improvements, usually based on quantified energy savings obligations with certification of energy savings (via white certificates), and the option to trade them. However, implementing energy saving obligations involves a set of administrative tasks related to enforcing the scheme, including measurement and verification of project savings and standard registration tasks. Furthermore, a specific body responsible for the organisation and the maintenance of the white certificate trading platform is necessary.[134] Considering all these requirements, the transferability across countries is considered low.

[133] Bertoldi, P. and Economidou, M. (2014). *Financing Building Energy Renovations*.
[134] Bertoldi P. and Rezessy S. (2009). Energy Saving Obligations and Tradable White Certificates.

Health and wellbeing - Factsheet

Author: Vivian Dorizas, Janne Rieke Boll

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7.1 Introduction

This factsheet provides an overview of how different policy instruments and selected private initiatives can help to achieve European objectives and effectively address key EU challenges in the strategic area of **health and wellbeing**. The findings draw upon a policy screening for 15 EU Member States, 3 non-EU countries and 5 European regions covering broadly the climatic zones of the EU. In addition, the factsheet draws on additional information provided by external experts as well as on the long-standing expertise of the authors, meaning policy examples going beyond the researched country and region cases are occasionally added. The concluding assessment draws on the findings and detailed analysis of the good practice cases as well as on the in-house expertise of the partners.

7.2 Health and wellbeing

As people spend about 90% of their time indoors, the indoor environment has a significant effect on their health and wellbeing.[135] A great number of scientific studies show that the indoor environmental quality (IEQ) plays a crucial role in ensuring the quality of life and general health and wellbeing of occupants.[136] The major determinants of IEQ are indoor air quality, thermal comfort, acoustics and lighting. In addition to improving IEQ, energy efficiency renovation improves air quality by reducing fossil fuel use.[137] Reduction of energy consumption through building renovations also reduces energy poverty. Finally, energy efficiency renovations coupled with the elimination of accessibility barriers are also associated with increased wellbeing of occupants.

The revised Energy Performance of Buildings Directive (EPBD) has sparked a change towards the right direction by including elements of health, comfort and air quality. Article 2a of the EPBD requires Member States to incorporate in their long-term renovation strategy (LTRS) an evidence-based estimate of expected energy savings and wider benefits, such as those related to health, safety and air quality. The Commission Recommendation on building renovations[138] clearly mentions that measures to address energy performance can contribute to the creation of a healthy indoor environment and spells out some of the wider benefits related to health and wellbeing, such as lower illness and health costs and greater labour productivity from better working and living conditions.

The transformation towards an energy-efficient building stock will simultaneously have positive effects on the health and wellbeing of occupants. An important driver of healthy buildings are sustainable building certification systems, which set standards in areas such as indoor environment, ecology, sociocultural aspects, active and healthy lifestyles, and safety. They include the German Sustainable Building Council's DGNB[139], the Leadership

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[135] WHO (2012). Burden of disease from Household Air Pollution for 2012. World Health Organization

[136] Al horr et al. (2016). Impact of indoor environmental quality on occupant well-being and comfort: A review of the literature, *International Journal of Sustainable Built Environment* 5(1):1-11.

[137] EPA, Environmental Protection Agency, (Available at: https://www.epa.gov/indoor-air-quality-iaq/health-energy-efficiency-and-climate-change)

[138] Commission Recommendation (EU) 2019/786 of 8 May 2019 on building renovation

[139] The German Sustainable Building Council developed a voluntary certification system, the DGNB system. https://www.dgnb.de/en/

in Energy and Environmental Design (LEED) rating system[140], the BREEAM assessment method[141], the Irish Home Performance Index[142] and the WELL Building Standards.[143]

The three identified key challenges in the strategic area of health and wellbeing are:

1) Integrating health, wellbeing and comfort aspects in legislation and policy instruments associated with renovations.

2) Enforcing and mainstreaming existing IEQ provisions (e.g. through EN and ISO standards) in Member States

3) The lack of systematic quantification of health and wellbeing benefits and their integration in the cost-optimal methodology to boost the renovation rate.

This factsheet gives an overview of the legislative and non-legislative provisions in the focus countries which address these challenges. The identified measures are assessed on their effectiveness to tackle the key challenges, and good practice examples are highlighted.

7.3 Provisions to address key challenges

This section gives an overview of the policies considered to be most successful at tackling key challenges in the area of health and wellbeing. To operationalise the challenges and allow for quantitative estimations on selected aspects, the country screening looked for provisions that integrate IEQ in policy instruments, alleviate energy poverty, establish IEQ requirements and guiding documents, are certification schemes or include accessibility provisions.

Figure 1 provides an overview of the policy screening. Since countries vary in size, the number of provisions does not necessarily reflect the effectiveness of the policy mix. While the number of provisions found may give an indication of the breadth and diversity of approaches, it should not be taken as the sole indicator for how effective the provisions are for tackling key challenges. One well-designed policy instrument may be more effective than a multitude of less adequate instruments. Therefore, an additional qualitative discussion as well as insights from the good practice analysis are provided in the remaining parts of the paper.

Many of the analysed countries have aspects of health and wellbeing integrated in their legislative or non-legislative building policies, while several provisions address the key identified challenges to a varying degree. Table 1 gives a qualitative overview of the main aspects addressed per country or region, while Figure 2 shows the number of provisions for the examined aspects.

The category *'integration of IEQ in policy instruments'* refers to measures that improve IEQ, reduce negative health effects and remove harmful substances from the indoor environment (Figure 2, dark blue bar). National policies regulating the energy efficiency of buildings often mention improved living conditions covering thermal comfort and better

[140] LEED, Leadership in Energy and Environmental Design rating system, https://www.usgbc.org/leed

[141] BREEAM, Building Research Establishment Environmental Method, https://www.breeam.com/engage/research-and-development/consultation-engagement/active-design-and-breeam/

[142] Home Performance Index certification, http://homeperformanceindex.ie/

[143] The WELL Building Standards https://www.wellcertified.com/

air quality as drivers for renovation (e.g. Warmth and Well-being scheme [Ireland][144], Clean Air Programme [Poland][145], Planning and Building Ordinance 2011 [Sweden]). Research projects, on the other hand, develop new technologies or strategies to improve and monitor the indoor climate (e.g. PRO-CLIMAT [Brussels][146], Solbjerg skole [Denmark][147]). The removal of harmful substances contributes to better indoor climate and is taken up by different provisions, for example in the planned asbestos removal bonus[148] in Flanders, Belgium, the asbestos fund of the Netherlands[149] and the Radon grant[150] in Sweden. In addition, regulations reducing noise in residential buildings are implemented in France (Energy and acoustic renovation)[151] and Sweden (Ordinance on traffic noise in residential buildings[152]) and are supported by a grant in Umeå, Sweden (Grant for noise protection[153]).

The '*IEQ requirements and guiding documents'* cover concrete IEQ criteria such as for thermal comfort and ventilation and national guidelines on how to design and operate healthy indoor environments, but also guiding documents and platforms promoting healthy living (e.g. Platform live healthy[154], healthy housing[155] in Germany) (Figure 2, red bar). Ventilation requirements (in l/s per person) are included in building codes in most countries, such as Germany, UK, Poland, Greece and Romania but are not always compulsory. Mandatory ventilation requirements are implemented in Denmark, France, Italy, Ireland, Netherlands, Norway and Sweden. Additionally, most countries have national standards in place adopted by a corresponding European standard (e.g. ΕΛΟΤ EN

13779 in Greece, DIN EN ISO 13791 in Germany, SR EN 16798-1 in Romania etc.) that are not represented in the diagram. The Netherlands, for example, has non-legislative guidance documents providing principles on healthy[156] and comfortable indoor environments as well as a coalition of stakeholders[157], developing a healthy building governance code in order to get health and wellbeing on the agenda of the Dutch government.

The category '*certification schemes'* refers to voluntary building certification schemes in place that are implemented by either private actors or national green building councils and consider health and wellbeing aspects (Figure 2, green bar). LEED certification, which takes the whole lifecycle of a building into account, is international and is used in many of the analysed countries (e.g. California, Italy, UK, Greece). The WELL building standard was more recently launched (in 2014) and has also been adopted in many of the analysed countries such as the UK, Italy and Sweden. The WELL standard sets a stronger focus on the health of occupants. Another certification scheme is the BREEAM system developed in the UK, which is also used in the Netherlands, Norway, Sweden and Spain. Additionally, national certification systems are implemented in Germany (DGNB), Italy (BioSafe[158]), Ireland (Home Performance Index) and California (Living Building Challenge 4.0[159], Indoor airPLUS label[160]). France launched its E + C -[161] (Positive Energy and Carbon Reduction Building) label in 2016 to foreshadow future energy regulation and performance standards, representing a step towards Level(s), the European common reporting framework of sustainable performance of buildings. Level(s) brings the key aspects of a building's sustainability performance beyond the use-phase energy consumption into focus, with health and wellbeing among being one of the key areas.

As these are voluntary certification schemes, they only address the first key challenge regarding the integration of IEQ parameters in policy instruments but do not necessarily support enforcement. However, legal provisions in the United States such as the King County Green Building Ordinance[162], aim at making LEED certification mandatory, which can indeed support enforcement. Most certification systems were initially developed for commercial and institutional non-residential buildings but are increasingly applied in residential building projects as the demand for a healthy indoor environment and sustainable housing is rising and certification can enhance the value of properties.

'*Energy poverty alleviation'* refers to instruments promoting the elimination of energy poverty (Figure 2, purple bar). Energy poverty provisions are implemented in 11 out of 24 regions/countries. Renovation and energy saving measures for vulnerable residents are highly supported by grants or offered at no cost for the residents in Ireland (Warmth and wellbeing scheme, Warmer Homes scheme[163]) and Scotland, UK (Warmer Homes Scotland Scheme[164]), while Croatia launched a consulting and capacity building programme[165] around energy poverty and established a programme for combating energy poverty that provides co-financing for energy efficiency measures to vulnerable consumers.

'*Accessibility provisions'* refer to social equality aspects and measures that eliminate accessibility barriers for people with disabilities (Figure 2, light blue bar). Accessibility is often addressed by grants (Support for barrier-reduction fund[166] [Saxony, Germany]), standards or guidelines but usually not in legislative provisions. Exceptions include regulations for people with disabilities in for example California[167] and Greece[168] and the accessibility chapter in the building codes of Denmark, Ireland,[169] Sweden[170], and the Netherlands. Most provisions on this topic have been identified in Germany (e.g. standards on barrier-free housing and thermal performance), Sweden and Tirol (Figure 1).

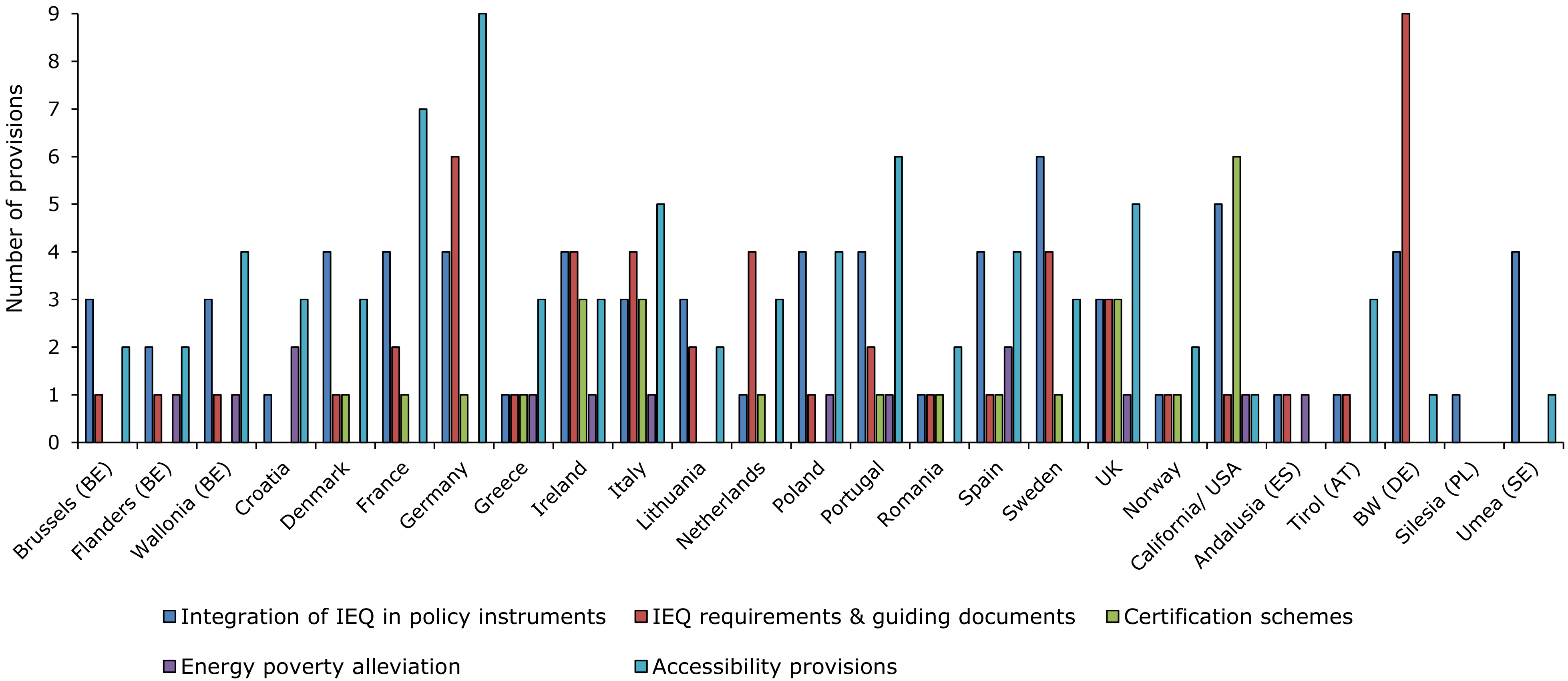
The Federal Disability Act covers accessibility in the built environment in Austria. All three regions of Belgium have technical prescriptions and guidelines on accessibility. In particular, the Flemish Decree supports urban development for the accessibility of public buildings, the Walloon Code guarantees accessibility to public and private buildings for people with reduced mobility and disability, and the Regional Urban Development Regulation of Brussels sets the rules for public space adaptation. Royal Decree 505/2007 in Spain approves the conditions on accessibility of people with disabilities to be able to access public spaces and buildings and sets out accessibility standards in public spaces and infrastructures.

The 1994 Law on construction in Poland introduced the obligation to consider the needs of people with disabilities in new construction projects but also when modernising existing public and multi-family buildings. A new programme called Accessibility Plus was announced in 2018 aiming to make 1,000 public facilities accessible to disabled persons, including schools (100), nurseries (100), universities and healthcare centres.

The accessibility law (Decree-Law 163-2006) of Portugal defines accessibility standards for public buildings, facilities and spaces and covers general norms and principles to be applied in residential buildings. For the protection and promotion of rights of people with disabilities, accessibility measures related to public buildings were included by the National Institute for Rehabilitation law 448/2006 of Romania; however, many public buildings remain inaccessible for people with wheelchairs. According to the National Disability Strategy, the main reason for this is the lack of a strict commitment to ensure accessibility of local and central authorities. The Building Code of the Netherlands governs usability including accessibility, but contains no sanction if the regulations are violated. In Italy, several laws cover the right of accessibility such as the Decree 114 containing guidelines for the elimination of architectural barriers in places of cultural interest and the Presidential Decree 503 regulating the removal of architectural barriers in public buildings.[171]

The quantification of health and wellbeing benefits seems to be addressed to a much smaller extent. There are no mandatory policies in place addressing the topic in the analysed countries, although a few non-legislative initiatives and research projects (e.g. in a Danish school in the city of Aarhus) tackle the issue. The regional internal pollution intervention unit in Belgium, in addition to carrying out indoor pollution diagnostics upon medical request, monitors the improvement of health which can be a starting point for the quantification of health and wellbeing benefits from building renovations. The Coalition Healthy Buildings[23] in the Netherlands is developing a system/model for appraising the value of healthy buildings based on guaranteed performance that is accepted by institutes, banks and investors.

[171] The Academic Network of European Disability Experts (ANED), DOTCOM: the Disability Online Tool of the EU Commission.



Note: National provisions are not counted in the regions

Figure 6 - Key aspects of health and wellbeing per country

Table 10: Overview of policy instruments on health and wellbeing per country

Country	IEQ requirements (ventilation, thermal comfort etc.)	Accessibility provisions	Provisions alleviating energy poverty	Certification/labelling systems (excl. EPCs)	Quantification of health & wellbeing
Andalusia	√		√		
BW	√	√			√
Brussels	√	√ (research project)		√ (on national level in Belgium)	
Flanders	√		√		
Wallonia	√	√	√		
California/ USA	√	√	√	√	
Croatia			√		
Denmark	√	√		√	√
France	√			√	
Germany	√	√		√	
Greece	√	√	√		
Ireland	√	√	√	√	
Italy	√	√	√	√	
Lithuania	√	√			
Netherlands	√	√		√	√
Norway	√			√	
Poland	√	√	√		√
Portugal	√	√	√	√ (EPC incl. IAQ)	
Romania	√	√		√	
Silesia					
Spain	√	√	√	√	
Sweden	√	√		√	

Tirol	√	√			
UK	√	√	√	√	
Umea		√			

7.4 Effectiveness of the policy landscape to address key challenges – overview and description

This section presents an assessment of the overall policy landscape that a previous country screening identified as relevant for the covered countries and regions. The assessment takes into account the diversity of instruments (regulation, pricing, support, information etc.), whether there are particularly interesting and innovative instruments, and whether the instruments identified together seem to be adequate to address the given challenges. A discussion of policy instruments follows the tables.

The given classification in Tables 2 and 3 should be interpreted as follows:

	Good policy landscape with at least one innovative instrument targeting health and wellbeing
	Adequate policy landscape with instruments that could in the future better integrate health and wellbeing in building renovation policies
	Inadequate policy landscape, with no instruments identified in relation to the given challenges
	Not conclusive

Table 2 – Legislative policies

	Health and wellbeing – legislative policies		
	KEY CHALLENGES		
	Integrating of health, wellbeing and comfort aspects in legislation and policy instruments associated with renovations	Enforcing and mainstreaming existing IEQ provisions in Member States	Quantifying health and wellbeing benefits from building renovations and integrating them in the cost-optimal methodology to boost the renovation rate
Belgium			
Croatia			
Denmark			
France			
Germany			
Baden Wurttemberg			
Greece			
Ireland			
Italy			
Lithuania			
Netherlands			
Poland			
Portugal			
Romania			
Spain			
Sweden			
UK			

Norway			
California/ USA			
Andalusia			
Alpine (Tirol)			
Silesia			
Umea			

Table 3 – Non-legislative policies

	Health and wellbeing – non-legislative policies		
	KEY CHALLENGES		
	Integrating health, wellbeing and comfort aspects in legislation and policy instruments associated with renovations	Enforcing existing provisions in support of IEQ	Quantifying health and wellbeing benefits from building renovations and integrating them in the cost-optimal methodology to boost the renovation rate
Belgium			
Croatia			
Denmark			
France			
Germany			
Baden Wurttemberg			
Greece			
Ireland			
Italy			
Lithuania			
Netherlands			
Poland			
Portugal			
Romania			
Spain			
Sweden			
UK			
Norway			
California/ USA			
Andalusia			
Alpine (Tirol)			
Silesia			
Umea			

1) Integrating health, wellbeing and comfort aspects in legislation and policy instruments

In Sweden, the Building Ordinance (Planning and Building Ordinance (2011:338)[172]) states that buildings should be designed in a way that does not create health issues related to indoor air pollutants such as hazardous particles or gases in the air, smoke and presence of moisture on the buildings' surfaces. In addition, buildings shall have technical characteristics related to protection against noise. Obligatory ventilation control (based on the Planning and Building Act (2010:900)[173]) is applicable to all buildings and must be performed regularly to check if the indoor climate is good and the ventilation systems are functional. The Danish building code integrates similar ambitious IEQ requirements, including regulations on daylighting and noise protection.

California applies a great number of national and state-level certification schemes (e.g. US EPA Indoor airPLUS label, GreenPoint Rated[174] etc.) which cover topics either partially or entirely related to IEQ and therefore health, wellbeing and comfort. The integration of these aspects in legislation is supported by building ordinances that make building rating systems such as LEED mandatory. LEED considers indoor air quality as an assessment criterion.

The Polish Clean Air programme[175] aims to improve air quality by allowing homeowners of specific income levels to get a grant or subsidy for the thermal modernisation of their building.

In the Brussels capital region of Belgium, awareness raising campaigns[176] on indoor air quality, the use of highly emissive building materials and products and improving health are part of the sustainable building guide. In Flanders, a legislative provision is planned to financially support the renovation of roofs containing asbestos.

In support of the integration of health and wellbeing aspects in policy instruments, Germany has developed a series of platforms and guidelines on healthy housing and air pollutants (e.g. Healthy housing platform[177] , health living[178]).

As part of the housing renovation directive in Tirol, the regional government offers grants for reducing pollutant emissions[179] and improving comfort.

The guidelines[180] for energy efficiency and ventilation in the UK are in approved documents of the building regulations giving guidance on airtightness and ventilation and specifying air quality standards for limited substances. While these regulations apply for both new and renovated buildings, they are most likely to be enforced for new buildings. Indoor air

[172] Planning and building Ordinance 2011:338 Chapter 3 section 9: requirements for the protection with regard to hygiene, health and environment, Swedish Ministry of Finance

[173] Planning and Building Act 2010, Chapter 8, section 25 and the Planning and Building Ordinance Chapter 5, §1, Swedish Ministry of Finance

[174] GreenPoint Rated certification system by Build It Green organisation, California, US

[175] Clean Air Programme (2018-2029), National Fund for Environmental Protection and Water Management, Poland

[176] LTRS Brussels, p. 91 (Action 19), Government of the Brussels-Capital Region

[177] *Gesund Wohnen,* Online Magazine for healthy living, www.gesund-wohnen.com

[178] *Wohnen Sie gesund*, information portal on healthy housing, "Zukunftsinitiative Handwerk" (ZIH), Economic ministry of North Rhine-Westphalia

[179] Single grant for construction measure, §35 Tirolean Housing Promotion Act, LGBl. No. 144/2018, Tirol regional government

[180] UK Indoor Air Quality, Approved Documents of the Building regelation, Parliamentary Office of Science and Technology, House of Parliament, UK

quality can be improved through changes to regulations, such as giving greater emphasis on ventilation and setting air quality standards for common air pollutants.

Within Lithuania's technical building regulations[181] and hygiene standard[182], IEQ requirements are found.

Air protection programmes[183] of Silesia aim to achieve acceptable levels of pollutants in the air.

Another good example can be found in Finland where ARA, the Housing Finance and Development Centre, grants subsidies[184] for residential building owners and owners of housing units that show humidity or microbial damage or other indoor air problems. Support can also be granted for the renovation planning phase.

2) Enforcing and mainstreaming existing IEQ provisions in Member States

France sets minimum requirements for ventilation[185] and mandatory labelling of construction products[186] to limit the sources of indoor air pollutants.

In Denmark, the private initiative Clean Air School Districts[187] offers monitoring instruments, educational material and consultation services to students, teachers and parents on improving the IEQ of the schools.

Germany has adopted a great number of EN ISO standards related to the IEQ dealing with ventilation requirements[188], construction products[189], assessment and evaluation of the release of dangerous substances.[190]

Norway has implemented building technical regulations that include provisions and requirements related to all determinants of IEQ (thermal comfort, indoor air quality, ventilation and radon accumulation[191]).

New and renovated buildings should meet requirements[192] of natural ventilation, lighting, acoustics and material emissions in Italy.

[181] Technical Building Regulations STR 2.09.02: 2005 "Heating, Ventilation and Air Conditioning" and STR 2.01.01 [5]: 2008 "Essential requirement for construction", "Noise protection", MINISTER OF THE ENVIRONMENT OF THE REPUBLIC OF LITHUANIA

[182] Lithuanian Hygiene Standard HN 42: 2009 "Microclimate of Residential and Public Buildings", MINISTER OF HEALTH OF THE REPUBLIC OF LITHUANI

[183] Air protection program for the Silesian region, Resolution NO VI / 12/7/2019 of the Slesian regional government

[184] LTRS Finland, p. 39, Long-term renovation strategy 2020–2050 FINLAND, European Commission website, 2020

[185] Order of June 13, 2008 relating to the energy performance of existing buildings with a surface area greater than 1,000 square meters, when they are the subject of major renovation works, Ministry of State, Ministry of Ecology, Energy, Sustainable Development and Regional Planning, and the Ministry of Housing and City, France

[186] Order of April 19, 2011 relating to the labeling of construction or wall or floor covering products and paints and varnishes on their emissions of volatile pollutants, Ministry of Ecology, Sustainable Development, Transport and Housing, the Ministry of the Economy, Finance and Industry and the Ministry of Labor, Employment and Health, France

[187] Clean Air School Districts (CASD) campaign by leapcraft, Denmark

[188] DIN CEN/TR 16798-6 and DIN SPEC 32739-6 Energy efficiency of buildings - Ventilation of buildings, DIN (German national organization for standardization)

[189] DIN EN 16687 Construction products - Evaluation of the release of dangerous substances - Terminology

[190] DIN EN ISO 10456 Construction products - Assessment of the release of dangerous substances - Barriers to trade

[191] Building Technical Regulations TEK 17- Indoor Air Quality (Article 13.1-13.3), Thermal Comfort (13.4) and Radon removal (Article 13.5), Norwegian Building Authority

[192] Minimum environmental criteria for entrusting design services and works for the new construction, renovation and maintenance of public buildings, Interministerial Decree of 11 January 2017, Italy

Under the revised energy efficiency regulation of buildings in Greece (KENAK 2017), the technical chamber of Greece has published technical specifications[193] for the estimation of the energy efficiency of buildings which specify requirements of the indoor environment covering aspects of thermal comfort, ventilation and lighting.

The energy performance certificate (EPC) in Portugal also covers indoor air quality and natural ventilation is given priority over mechanical ventilation. The EPC also specifies minimum values of fresh air rates and thresholds for concentrations of air pollutants in order to safeguard the health and wellbeing of occupants.

3) Quantifying health and wellbeing benefits from building renovations and integrating them in the cost-optimal methodology to boost the renovation rate

In general, there is a lack of cases quantifying the health and wellbeing benefits from building renovations across the analysed countries. The listed provisions only touch upon the topic but do not particularly help in addressing this challenge.

In Denmark, recent research in a school in Aarhus (p.17) quantified the benefits on health and productivity arising from building renovations; however, there is no standardised methodology for calculating the health, wellbeing and productivity benefits arising from building renovations.

The cost of poor air quality and the effects of air pollution on the environment and human health can be found in the air protection programme of Silesia; however, no details are given on the calculation method behind the estimation of these costs.

Even though the regional internal pollution intervention unit[194] in Brussels, Belgium carries out indoor pollution diagnostics on medical request, monitors the improvements on health and evaluates the indoor environmental conditions, the benefits on health and wellbeing are not thoroughly quantified.

[193] Technical instructions of the Technical Chamber of Greece, National analytical specifications for the estimation of the energy efficiency of buildings and the issuance of the energy performance certificate, KENAK 2017

[194] Cellule Régionale d'Intervention en Pollution Intérieure (CRIPI), Bruxelles Environnement / Département Planification Air, Climat et Energie, Belgium

7.5 Highlighting good practice examples

Based on the results of the previous research as well as on expert knowledge, this section highlights selected good practice examples. Each example fulfils one or several of the following selection criteria: innovation (new mechanism, triggering innovation, scaling up innovation), impact (on EU objectives, energy savings, CO_2 emission reduction, potential renovation impact), ease of implementation (including transferability, scalability, transaction and administrative costs, budget (in-)dependency, compatibility to existing legislative/ policy framework) and coverage of diverse jurisdiction and climatic zones.

Country	Policy	Brief description	Source
Belgium	Strengthen diagnostic and remediation services for interior pollution- (Regional Internal Pollution Intervention Unit [Brussels])	In addition to carrying out indoor pollution diagnostics on medical request, the regional unit is responsible for: • Monitoring the improvement of health • Statistical evaluation of the environmental condition of the interiors of diagnosed buildings • Developing recommendations for decision support.	PACE p.132
California	Healthy Housing Rewards (Federal National Mortgage Association – Fannie Mae)	Fannie Mae provides financial incentives (loans) to lenders for: • Healthy Housing Rewards Healthy Design: if the property incorporates health-promoting design features and practices • Healthy Housing Rewards Enhanced Resident Services: if the property offers services to improve the health and stability of residents.	https://multifamily.fanniemae.com/sites/g/files/koqyhd161/files/migrated-files/content/fact_sheet/healthy-housing-rewards-flow-chart.pdf
California	(1) Green Building Ordinance (2) King County Green Building Ordinance 17709 (3) A resolution promoting the use of LEED standards in the	(1) This mandatory building ordinance implemented in San Mateo, California specifies that all new or remodelled commercial buildings over 3,000 square feet must earn LEED certification (2) King County, with regard to green building, should direct county departments to incorporate the use of the LEED green building rating system. (3) The Bellingham City Council requires all new municipal building construction and renovation over 5,000 square feet, and where the city provides a	37122 Comprehensive update of the Green Building policy King County Green Building Ordinance Resolution No.2005-21

	construction and renovation of city buildings and in the construction practices of the private sector	majority of the funding, to earn LEED Silver certification.	
Denmark	Building regulations for good indoor climate	• Minimum requirements: have access to daylight or protection against noise, air quality; limiting the presence of harmful substances. • It must be ensured that hazardous substances such as asbestos, PCB, lead or particles from insulation materials from already built-in materials are not spread to the indoor climate.	https://bygningsreglementet.dk/~/media/Br/BR-English/BR18_Executive_order_on_building_regulations_2018.pdf
Ireland	Warmth and Well-being Pilot Scheme (running under the Better Energy Programme, initiated by the Department of Communications, Climate Action and Environment, the Department of Health and the Health Services Executive).	• Building occupants with chronic respiratory conditions (mainly older people and children) are eligible for a free home insulation upgrade.	www.seai.ie/grants/home-energy-grants/free-upgrades-for-eligible-homes/warmth-and-wellbeing
Ireland	Home Performance Index	• Ireland's first national voluntary certification system for quality and sustainable residential development. • Health and well-being is one of its main categories.	http://homeperformanceindex.ie/wp-content/uploads/2020/01/HPI-Technical-Manual-v2.0.pdf
Poland	Clean Air Programme (Institution implementing the National Fund for Environmental Protection and Water Management)	• Allows building owners on low incomes to get a subsidy for the thermal modernisation of the building aiming to improve the air quality.	https://czystepowietrze.gov.pl
Portugal	Certificate of Energy Performance and Indoor Air Quality, 2013	• In existing buildings, the energy certificate provides information on measures to improve energy performance and indoor air quality • With regard to indoor air quality, natural ventilation is given priority over mechanical ventilation equipment.	www.iea.org/policies/2547-certificate-of-energy-performance-and-indoor-air-quality-2013?country=Portugal&page=2&qs=portug

		• Sets minimum values of fresh air flow per space and thresholds for concentrations of indoor air pollutants, in order to safeguard the health and well-being of the occupants.	
Sweden	Radon Grants	• Grant for Radon remediation for homeowners.	www.boverket.se/sv/bidrag--garantier/radonbidrag/
Sweden	Obligatory ventilation control for housing	• Obligatory ventilation control applicable to all buildings and must be performed regularly to check if the indoor climate is good and the ventilation systems are functional.	www.boverket.se/en/start/building-in-sweden/swedish-market/laws-and-regulations/national-regulations/obligatory-ventilation-control
Umeå	Grants for noise protection	• The municipality provides grants to reduce noise disturbance from road traffic or other outdoor noise sources. • The grants are applicable to improve the acoustic insulation of windows.	www.umea.se/umeakommun/byggaboochmiljo/bullerochluftkvalitet/buller/bullerskyddsbidrag.4.232bb3eb132b9e0c2ca800068080.html
US	WELL Building Standard	• The WELL Building Standard was developed in the USA but now applied in several European countries (e.g. Italy, the Netherlands and Poland) • Certification criteria are air, water, nourishment, light, fitness, comfort and mind, which are measured and monitored.	www.wellcertified.com
UK	BREEAM certification scheme	• The BREEAM (Building Research Establishment Environmental Assessment Methodology) scheme is a another building certification scheme incorporating health and wellbeing standards. • The standard covers schemes for construction and planning, in-use and refurbishment of non-residential and domestic buildings	www.breeam.com

7.6 Concluding assessment

The key identified challenges of the policy area of health and wellbeing are tackled to a varying degree. Many of the analysed countries have some form of IEQ provisions implemented in their building renovation policies, often as standards, guidance or voluntary requirements. Also, national certification schemes, research projects and awareness raising campaigns integrate health, wellbeing and comfort aspects.

In order to better asses the effectiveness and impact of existing provisions, an ongoing close monitoring of the policies is essential to increase the data availability (for IEQ this is still very limited). In particular, private programmes and initiatives, e.g. building standards/ certifications, are often not monitored or the data is not publicly available.

Compared to the mere existence of provisions, the enforcement of IEQ is less advanced. This can partly be explained by the lack of harmonised methodologies and criteria at EU level. Countries like Sweden, Denmark, France, Italy and Ireland apply legislative (mandatory) IEQ requirements (e.g. ventilation and thermal criteria). Dedicated polices regarding noise protection are less often found but are implemented in Sweden and the Swedish region of Umeå.

Additionally, building certification schemes as well as EPCs covering IEQ aspects could spur enforcement when their implementation is mandatory. Among the good practice schemes is California, which requires certain commercial and municipal new buildings to be LEED certified. Also, the Portuguese EPC incorporating requirements for minimum fresh air rates and thresholds for concentrations of indoor air pollutants offers aspects to replicate.

Assessment of impact per type of policy instrument

Policies aimed at improving IEQ do not necessarily have an effect on energy savings or greenhouse gas emission reductions, which makes a general impact assessment difficult. It becomes clear when assessing impact that policies that solely address the improvement of health and wellbeing, such as radon removal, noise protection or accessibility, do not always lead to the improvement a building’s energy efficiency.

Voluntary and private certification schemes can be effective in reducing energy use and greenhouse gas emissions if they are widespread in the building stock (compare mandatory certification in the US). Indicators of health and wellbeing could improve EPCs and encourage their utilisation as renovation advice instruments triggering deeper renovation.

The impact of financial support schemes that are often implemented in the form of grants (e.g. Swedish noise protection or radon removal grant) is high regarding the alleviation of IEQ issues, though they do not always add to energy savings or greenhouse gas emission reductions unless embedded in a relevant policy framework.

Informative measures which increase awareness on the importance of health and wellbeing aspects when renovating, especially residential and educational or recreational buildings, are often effective to trigger deep retrofits. A holistic monitoring and quantification of these benefits is important to communicate them to the relevant stakeholders (e.g. building owners).

Regulations set in the building codes of many countries are effective when they are mandatory provisions and cover not only specific ventilation requirements but have thermal comfort, lighting and noise requirements, as in Denmark.

Ease of implementation per type of policy instrument

The Danish building code shows a good example of a progressive integration of mandatory thermal comfort, lighting and noise requirements that are not yet implemented in other Member States. The transferability could be increased by an amended EU legislation (EPBD) demanding a stronger integration and enforcement of IEQ requirements.

Most policies are administered at the national level, although some American and Swedish regional authorities have implemented ambitious policies (mandatory certifications, grant schemes). Guidance at EU level allowing some flexibility to be tailored at national level with country-specific requirements would strongly facilitate implementation.

Although the Joint Research Centre has published a report on Promoting healthy and energy efficient buildings in the European Union'[195] showing various studies that have quantified the benefits in terms of improved quality of life, a systematic quantification approach of health and wellbeing benefits among EU countries is lacking. Some research projects (e.g. Denmark, Belgium) were identified but a large-scale integration of quantified IEQ benefits in cost-optimal calculations is missing.

Accessibility provisions are implemented in most of the analysed countries in the form of standards, guidelines and grants to adapt the building to users' needs (cf. Germany, Umeå). However, they are not systematically used to trigger deep energy renovation or vice versa. Yet in Poland, when modernising existing public and multi-family buildings, the needs of people with disabilities should be considered.

Strategies addressing energy poverty are mostly implemented in countries where energy poverty is widespread and on the political agenda, as in England (UK)[196] and Ireland[197]. Greece, Italy, France and Croatia have also planned or applied provisions to alleviate energy poverty through financial support schemes[198], monitoring platforms[199] and education campaigns[200].

Despite the good practice policies and initiatives presented in this factsheet, regulatory and legislative measures have so far failed to fully integrate health and wellbeing aspects in building legislation. Though the impacts of the indoor environment on building occupants are researched intensively, it is still a challenging and complex procedure to isolate and quantify the benefits to health, wellbeing, comfort and productivity from building renovation. Communication campaigns to increase the awareness of IEQ among building occupants and owners should be implemented at large scale to drive deep renovations.

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[195] Promoting healthy and energy efficient buildings in the European Union : National implementation of related requirements of the Energy Performance Buildings Directive (2010/31/EU)
[196] Fuel Poverty Strategy, England/ UK, Fuel Poverty Strategy Team, Department for Business, Energy and Industrial Strategy, UK
[197] Strategy to combat energy poverty, 2016-2019, Department of Communications, Energy & Natural Resources, Ireland
[198] 'Saving at home II' Programme (replacement of oil boilers with gas boilers to "low-income owners"), Croatia; 'Bonus sociale' (discounted energy bills for low income families), Italy
[199] National Observatory for Energy Insecurity, France, www.onpe.org
[200] Capacity building for combating energy poverty, measure H.3 of the 4th NEEAP, Ministry for protection of the environmental and energy, Croatia, 2017, p.34

Lessons learned to inform integrated approaches for the renovation and modernisation of the built environment

Annex III: Good practice examples

ENER/C3/2019-468/03

Written by:
Buildings Performance Institute Europe ASBL (BPIE),
CLIMACT SA,
Creara Consultores SL, and
Ecologic Institute

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CONTENTS

1 CRITERIA TO CHOOSE GOOD PRACTICE EXAMPLES

The following criteria have been considered to choose the good practice examples presented in this document. Please note that a good practice examples do not necessarily have to fulfil all requirements.

- Adequacy in addressing key EU challenges of the strategic area:
  - Fast carbon emission reduction
  - Contribute to long-term targets
  - Tailored to a challenge specific to the area
- Ease of implementation:
  - Possibility to scale up the policy (e.g. increase scope, rate or depth of renovations)
  - Replicability potential (How much depends on country-specific information? What is the degree of transferability across countries, regions, climate zones and building typologies?)
  - Low transaction and administrative costs including costs for preparing the policy
  - Possibility to implement it within existing regulatory framework
- Innovative approach:
  - A new mechanism to be used for a certain building segment/a certain objective
  - Triggers innovation
  - Boosts innovation

2 GOOD PRACTICE EXAMPLES: CLEAN AND SUSTAINABLE MOBILITY

2.1 Wallonia (Belgium) – Regional Mobility Strategy

Policy/initiative	**Regional Mobility Strategy (Stratégie Régionale de Mobilité)**
Location	Belgium – Wallonia
Start year	2019
Status	Ongoing
Building types	City level, district level
Type of policy	Strategy
Short description	Aiming at making transport safer, more fluid and more sustainable, Wallonia's mobility strategy sets clear overarching targets for emission reduction and modal shift (as well as security and reduction of gridlock). Based on this vision, it derives 10 strategic axes in three areas for orienting change, namely 1) mobility governance, 2) supply of transport options, and 3) demand for transport. The proposed action areas combine short-term and longer-term measures, often including measure-specific indicators adequate to monitor progress in the specific area. Chapter 8 focuses on urban and regional planning, declaring priority for centrality, density and diversity of activities so as to reduce the demand for transport and limit urban sprawl. Mobility issues are to be integrated from the design of new districts or new projects as well as in existing residential areas (e.g. pedestrian routes to public transport stops, pooling of parking and deliveries, space for public transport terminals or depots). As the next step, the strategy foresees plans at local and regional level breaking down implementation in concrete multi-year action programmes.
Primary energy savings	The strategy itself will not directly lead to primary energy savings, but it aims at triggering concrete measures which in total should reduce Wallonia's transport emissions by 40% by 2030 (compared to 2005).
CO_2 emission savings	See above.
Costs	The strategy does not contain a cost estimation.
Increased renovation rate and depth	Not applicable.
Ease of implementation	The policy, i.e. the process of developing a strategy for mobility on regional or national level, appears to be highly transferrable. While the priority areas and concrete measures have to be adapted to local circumstances, the overall approach of developing a vision, setting concrete targets, deriving principles, developing action plans and building an adequate multi-level governance structure can be replicated in other regions. The strategy covers the Belgian region of Wallonia, but the governance structure provides for taking into account and influencing action at national and local level. Compliance: The strategy explicitly recognises that governing change in the transport sector is the biggest challenge. It aims at implementing a governance structure that ensures that all public decisions in the transport sector contribute to achieving the Vision FAST goals. The Walloni an regional administration declares itself to be responsible for coordinating and monitoring compliance with the targets, establishing accountability for results. A monitoring system based a set of indicators is planned (some are already included in the

	strategy, local communities are required to formulate additional ones, e.g. on the km of bike lanes they plan to erect). Interaction with other measures: Due to its nature as an overarching strategy, the measure interrelates with many other measures, both strategies in a range of other policy areas and on other governance levels and concrete actions on the ground. The measure has a guiding character and therefore appears to be complementary.
Matching EU policy framework	The strategy contributes to and explicitly relates to Belgium's target under the EU Effort Sharing Regulation. Under the regulation, Belgium has to achieve a reduction in non-ETS GHG emissions of 35% by 2030 compared to 2005.
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment • Increase smart readiness of buildingss • Secure fair transition • Upgrade of urban context	The measure predominantly aims for an upgrade of urban context by strengthening sustainable transport infrastructure. The other aim is to improve quality of life in urban and village centres to reduce the need for mobility as well as urban sprawl. It specifically aims to also improve public health through strengthening active transport modes, i.e. walking and cycling. In a section on tariffs for mobility service, the strategy aims to address higher costs that can result from a mobility transition for rural households and aims to adjust tariffs for shared mobility so as to make them accessible for low-income households to ensure a fair transition.
Lessons learned	Since the strategy is relatively recent, it cannot be evaluated yet how successful it will be. However, key strengths appear to be: the strategic approach to transformation, i.e. a process building on a concrete vision; clear overarching and issue-specific targets; comprehensive strategic principles; new governance structures, including measures to initiate and monitor implementation on the ground. The key challenges of implementation include the need for cooperation from other governance levels. Successful implementation will only be possible if the national level, neighbouring regions and local communities are as committed to implementation as the regional administration is. For example the strategy aims to improve train traffic which will require coordination beyond the region. Moreover, the strategy proposes a new tariff approach building on the principle of mobility as a service. The vision is to provide every inhabitant with a mobility pass that allows access to all forms of shared mobility. Again, this endeavour will only be possible if the region can ensure cooperation with other actors, including local communities, other regions, the national government and transport operators.
Synergies	The mobility strategy is explicitly linked to the digitisation agenda as well as to economic, energy, climate policy and public health agendas. In addition to contributing to Belgium's climate targets, the strategy is expected to lead to better air quality, and to higher economic output (through more fluid transport)
Bibliography	• Wallonie (2017). Vision FAST, Vision de la mobilité wallonne à 2030. • SPW Mobilité et Infrastructures (2019). Stratégie Régionale de Mobilité, Volet I – Mobilité des personnes.

2.2 Portugal – Mobility and transport action plans for sustainable urban mobility

Policy/initiative	**Mobility and transport plans and action plans for sustainable urban mobility** (as element of measure bundle called 'decarbonising cities' – descarbonizar as cidades)
Location	Portugal
Start year	2020
Status	Planned
Building types	City, district-level
Type of policy	Strategy
Short description	The measures included in Portugal's NECP aim to put cities at the forefront of sustainable mobility by creating conditions for a paradigm shift in urban mobility. It encompasses a number of action items: • Develop and implement mobility and transport plans (PMT) or action plans for sustainable urban mobility (PAMUS) by cities and municipalities with more than 50,000 inhabitants or that are district capitals. • Promote demand management (passengers and goods) and urban planning in order to reduce the volume of travel (traffic) and the distance of travel. • Adopt tools to support management of mobility and information systems and technologies for IT-based mobility management. • Promote urban design that favours pedestrians over cars. • Promote greater inter-municipal cooperation, e.g. through densification, by offering essential services in all neighbourhoods.
Primary energy savings	Since the strategy is only starting, no information on primary energy savings is available.
CO_2 emission savings	Since the strategy is only starting, no information on CO_2 emission reductions is available.
Costs	According to Portugal's NECP, costs of the measures have not been estimated.
Increased renovation rate and depth	Not applicable.
Ease of implementation	Transferability: The core of the approach – demanding cities and larger towns draw up sustainable mobility plans based on certain principles – appears transferrable to other countries. Transferability will of course depend on the constitutional relationships between the national, regional and local level which may impede the national government's options to make such municipal plans mandatory. Governance: The measure is initiated at national level, but requires action at local level. Compliance: The NECP does not include information on compliance mechanisms. Relation to other policies: In addition to addressing GHG emissions, the measure aims at improving air quality.
Matching EU policy framework	The policy contributes to achieving Portugal's target under the EU Effort Sharing Regulation, stipulating that the country must reduce emissions in sectors that are not covered by the EU ETS by 17% by 2030 compared to 2005.

Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context	The measure’s focus is to achieve an upgrade of urban infrastructure, in particular transport infrastructure, but it is linked to a wider range of decarbonisation measures in cities. These include promoting green spaces and urban farming to improve microclimatic outcomes in cities to improve wellbeing and resilience against climate change. In the same bundle, the NECP includes a measure to improve energy efficiency of infrastructure (e.g. lightening, water infrastructure).
Lessons learned	Success factors: All local municipalities, not completely clear if plans are mandatory and how compliance will be checked. Needs more detail. Challenges: Lacks clear targets.
Synergies	The measures have synergies with efforts to improve digitalisation.
Bibliography	Government of Portugal (2019): Plano Nacional Energia e clima 2021-2030 (PNEC 2030), p.58f.

2.3 Denmark – Local mandatory norms on bike parking

Policy/initiative	Local mandatory norms on bike parking
Location	Denmark, municipal level
Start year	Diverse
Status	Ongoing
Building types	Residential multi-family buildings, commercial and public buildings.
Type of policy	Regulation
Short description	An increasing number of municipalities in Denmark have implemented regulation that makes it mandatory to install bike parking spots when a new building is constructed. The regulation forces developers to foresee facilities for bike parking in the planning for each project and include the costs for it when drawing up the budget for the construction. In most cases, the regulation covers different types of buildings and differentiates the number of minimum parking spots per building type. Building categories include offices or other workplaces, educational institutions, public traffic terminals, shopping centres, multi-family residential buildings, cultural and sports establishments, and squares and shopping streets. In addition to quantitative standards (how many bike parking spots) norms also include qualitative criteria, specifying e.g. how many parking spots should be covered by a roof as well as specifications on accessibility or distance to entrance. For the city of Copenhagen, the regulation established in 2015 set the following minimum standards: residential buildings, student housing, working places and shops need four bike spots per 100 m^2 surface area, senior homes need 1.5 spots per 100 m^2, and educational institutions need 0.5 spots per student and staff. The norm serves as a minimum threshold. The final number and design of bicycle parking facilities needs approval from municipal staff familiar with the impact of cycling on urban space and transport flows as well as the qualitative factors like accessibility.
Primary energy savings	A quantification of energy savings is not possible since bike parking spaces are only one factor in each individual transport decision – albeit an important one.
CO_2 emission savings	See above.
Costs	
Increased renovation rate and depth	Not applicable.
Ease of implementation	<u>Transferability:</u> The policy is highly transferrable. It is important, however, that the policy is integrated into a bundle of measures to promote bike riding, because parking spots alone will not lead to increased bike traffic if e.g. safe bike lanes do not exist. Moreover, the policy requires trained staff at the municipal level to inform developers and ensure enforcement. <u>Administration:</u> The policy is administered at the local level, but several national institutions support municipalities e.g. with best practice guides. <u>Compliance:</u> Compliance checks are included in standard construction oversight through municipal institutions and processes (building licence).

	Complementary measures: In Denmark, the measure is successful through a combination with other investments in bike traffic, in safe and convenient bike lanes.
Matching EU policy framework	The measure contributes to fulfilling Denmark's obligations under the EU Effort Sharing Regulation to reduce GHG emissions outside the EU Emissions Trading Scheme by 39% compared to 2005.
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context	The measures primarily aim at upgrading the urban context by establishing the infrastructure for cycling as a key sustainable transport option. At the same time, the measures contribute to addressing air pollution (by replacing the need for car-based transport), public health (by promoting an active form of transport) and improved quality of life (fewer accidents, less noise, more efficient use of scarce public space).
Lessons learned	Success factor: The mandatory norm makes sure bicycle parking becomes an integral part of building planning from the start. Integrating it in the planning process also reduces costs compared to add-on solutions to existing buildings. Challenges of implementation: Implementation requires trained staff in the relevant administration overseeing building licensing. Moreover, the measure will only be successful in increasing the share of trips made by bike if combined with public investments in safe bike lanes. For cities with a low numbers of bike lanes, the start might be relatively challenging.
Synergies	The policy has a synergy with the built environment strategic area: by shifting to a mode of mobility that uses public space devoted to transport more efficiently than car-based traffic, the measure can liberate public space for other uses, e.g. parks or other blue or green spaces.
Bibliography	Cycling Embassy of Denmark (2019): Bicycle parking. Cykelparkering i nybyggeri – Best practice og Københavnske erfaringer, Gehl for Københavns Kommune (2017). Cyklister er guld værd for byerne", Celis, Pablo & Nielsen, Malene Kofod, Trafik & veje, (Juni/juli 2016) Undersøgelse af cykelparkering / Vaner og adfærd ved cykelparkering i byen", Rambøll for Københavns Kommune (2015). "Idékatalog for cykeltrafik", Cycling Embassy of Denmark (2012). "Bedre samspil mellem cyklen og den kollektive trafik, Idekatalog", Trafikstyrelsen (2009).

2.4 Germany - Low-interest loans for municipalities

Policy/initiative	Low-interest loans for municipalities ("Investitionskredit Kommunen 208")
Location	Germany, national level supporting the municipal level
Start year	2012
Status	Ongoing
Building types	City level
Type of policy	Public loans
Short description	Germany's public development Kreditanstalt für Wiederaufbau (KfW) offers low-interest loans of up to €150 million per year to German municipalities who invest in their municipal infrastructure. Loans can be used to invest in schools and kindergardens, broadband internet access, water, sewage or tourist infrastructure and for redesigning traffic infrastructure.
Primary energy savings	Not available.
CO_2 emission savings	Not available.
Costs	Not available.
Increased renovation rate and depth	Not applicable.
Ease of implementation	Transferability: Whether the measure can be replicated elsewhere depends on the constitutional arrangements governing financial relationships between the national, regional and local levels of government and it may depend on availability of funds at national level. KfW enjoys positive ratings which allow it to borrow at negative rates in global capital markets. This is not the case for all Member States. This underlines the importance of EU lending institutions like the European Investment Bank and the importance of inter-EU solidarity. Administration: The measure is administered at national level, but demand comes from the municipal level where the investment planning and implementation takes place. Compliance check: Municipalities need to provide planning documents for receiving the loan and need to present documentation of their spending several months after pay-out. Complementary measures: The measure is one element of a comprehensive bundle of national-level measures supporting local municipalities in becoming more sustainable. It includes other grant and loan programmes by KfW, e.g. grant for model projects Smart city and loans for building efficiency improvements. Another key programme is the National Climate Initiative ('Nationale Klimaschutzinitiative – NKI'), the programme using Germany's receipts from auctioning EU ETS certificates to foster low-carbon investments. As part of the initiative, the German government finances the development of local climate change mitigation strategies and provides resources for the employment of 'climate change managers' in municipal administrations. In addition, it funds a number of programmes and projects enabling best practice exchange, e.g. provided by the Deutsche Institut für Urbanistik (see as a recent example a best practice guideline publication commissioned by Umweltbundesamt 2020). Moreover, as regulatory measure the federal government has adopted a number of changes in traffic rules

	that protect cyclists and walkers and enable municipalities to take additional action where needed.
Matching EU policy framework	The measure contributes to Germany's efforts for reaching its national GHG emission reduction target under the EU Effort Sharing Regulation (-38% by 2030 compared to 2005).
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context	The measure predominantly aims at increasing investments in urban infrastructure. It has no particular focus on sustainability, but it can be used for sustainable urban transformations.
Lessons learned	Strengths: The measure addresses a key challenge for urban transformation: the lack of investment capital in municipalities which hampers infrastructure renewal. Challenges: For indebted municipalities, loans – even from public banks – increase debt levels and may reduce financial wriggle room in the future. Due to lower tax revenues during the covid-19 pandemic, this problem is poised to exacerbate in the near future. As described in its national energy and climate plan, the federal government is increasingly forseeing grants to support municipalites in building infrastructure for increased walking and cycling (Federal Ministry for Economic Affairs and Energy, p. 95f.)
Synergies	The measure (and related KfW loan programmes) can also be used to support district approaches.
Bibliography	KfW (2020): IKK – Investitionskredit Kommunen, Website Kreditanstalt für Wiederaufbau. Federal Ministry for Economic Affairs and Energy (2020): Integrierter nationaler Energie- und Klimaplan. Umweltbundesamt (2020): Quartiersmobilität gestalten. Verkehrsbelastungen reduzieren und Flächen gewinnen, Leitfaden.

2.5 Belgium – Establishment of multi-modal stations called "mobipôles"

Policy/initiative	Establishment of multi-modal stations called "mobipôles"
Location	Belgium, regional government of Wallonia
Start year	2018
Status	Ongoing
Building types	City-level
Type of policy	Infrastructure investment
Short description	The "mobipôles" will offer various services and allow modal exchange for people, with car parks, in particular carpooling, secure bicycle shelters, bus, tram and new rapid bus lines perfectly connected co-working spaces, shared bicycles and cars, charging stations, etc. The infrastructure hub can take different forms depending on local needs. They can be located close to existing hubs like train stations or park-and-ride stations or can be created from scratch in city or village centres. Mobipôles aim to promote "smart mobility", that is to say a system that includes both sustainable, efficient and innovative solutions and mobility behaviours. The Wallonian regional transport strategy aims to implement a minimum of one mobipôle per local community by 2030. In 2019, the regional government of Wallonia has commissioned the construction of five pilot mobipôles which will cost €7.5 million.
Primary energy savings	Not available
CO_2 emission savings	Not available
Costs	Not available
Increased renovation rate and depth	Not applicable
Ease of implementation	
Matching EU policy framework	
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition	

• Upgrade of urban context (including access to sustainable mobility)	
Lessons learned	
Synergies	The policy has a synergy with the built environment strategic area: by shifting mobility to a mode that uses public space devoted to transport more efficiently than car-based traffic, the measure can liberate public space for other uses, e.g. parks or other blue or green spaces.
Bibliography	SPW Mobilité et Infrastructures (2019). Stratégie Régionale de Mobilité, Volet I – Mobilité des personnes. Belgium government (2019): Belgischge ïntegreerd Nationaal Energie-enKlimaatplan2021-2030. Wallonie (2019): 5 mobipôles pilotes en Wallonie, 09.01.2019.

2.6 Germany – Information hub for promotion of cycling

Policy/initiative	Information hub for promotion of cycling (Informationsportal zur Radverkehrsförderung)
Location	Germany, regional government of Baden-Württemberg
Start year	Upgraded to central information hub in the cycling strategy, published in 2016
Status	Ongoing
Building types	City-level
Type of policy	Capacity building tool
Short description	The regional government of Baden-Württemberg funds an information hub on all matters relating to cycling. It provides local authorities in the region with up-to-date information covering the following areas: legal provisions, financing, guidebooks, best practice examples, statistics and ideas for communication strategies. The tool contributes to the implementation of the regional government's cycling strategy (Ministry for Transport and Infrastructure Baden-Württemberg, 2016). It aims to increase the share of cycling in all trips to 16% by 2020 (up from 8% in 2008) and to 20% by 2030.
Primary energy savings	Not available. The guidebook is only one element in promoting infrastructure change that can enable a modal shift in cities.
CO_2 emission savings	Not available. The guidebook is only one element in promoting infrastructure change that can enable a modal shift in cities.
Costs	
Increased renovation rate and depth	Not applicable
Ease of implementation	
Matching EU policy framework	
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context	

(including access to sustainable mobility)	
Lessons learned	
Synergies	The policy has a synergy with the built environment strategic area: by shifting mobility to a mode that uses public space devoted to transport more efficiently than car-based traffic, the measure can liberate public space for other uses, e.g. parks or other blue or green spaces.
Bibliography	Ministry for Transport and Infrastructure Baden-Württemberg (2020): Informationsportal zur Radverkehrsförderung. Ministry for Transport and Infrastructure Baden-Württemberg (2016): Radstrategie Baden-Württemberg.

3 GOOD PRACTICE EXAMPLES: DIGITAL TECHNOLOGY

The following pages provide examples of good practice policies in the strategic area of *digital technology.*

3.1 France – Realise digital transformation of the PLANBIM 2022

Policy/initiative	Concrétiser la transformation numérique du bâtiment PLANBIM 2022 Realise the digital transformation of the PLANBIM 2022 building (BIM = building information modelling)
Location	French territories
Start year	2018
Status	Ongoing
Building types	Two tracks: new buildings and renovation
Type of policy	Capacity building, providing methods and tools, sharing of best practices, accompanying local actors in the buildings value chain, with a clear focus on SMEs
Short description	The aim of the "BIM 2022" plan is to provide professionals with concrete methods and tools to massively digitalise uses around two priority areas: 1) facilitating and guaranteeing the proper use of BIM and optimising the interactions between the different businesses through fine-tuning contracts and definition of standard clauses for the use of BIM 2) equip actors with the tools they need to work in BIM through training, the provision of adapted collaborative tools and dissemination in the territories. The French initative is inspired by the UK BIM initiative.
Primary energy savings	• Impact is expected to vary across the projects; benefits are expected in terms of time, cost and quality, improvements in the way of working and assets produced • No information available yet on the results nor on the targets of BIM 2022
CO_2 emission savings	• Impact is expected to vary across the projects; benefits are expected in terms of time, cost and quality, improvements in the way of working and assets produced • No information available yet on the results nor on the targets of BIM 2022
Costs	• Impact is expected to vary across the projects; benefits are expected in terms of time, cost and quality, improvements in the way of working and assets produced • No information available yet on the results nor on the targets of BIM 2022 • The BIM initiative has been fine-tuned in order to better meet the needs of French SMEs
Increased renovation rate and depth	• Impact is expected to vary across the initiatives • No information available yet on the results nor on the targets of BIM 2022
Ease of implementation	• The French BIM takes inspiration from the UK • As a process, BIM can be transferred to other countries and regions in the EU; however, it needs local adaptation to different regions • Other countries could develop similar initiatives 1) with a clear objective, 2) where implementation is mainly the responsibility of the local level, and 3) where the national level provides support through capacity building and

	structured exchange of best practices and showcases. The UK has already been working on BIM since 2011.
Matching EU policy framework	It can be expected that overall, the programme and its objectives will contribute to increased renovation rate and speed, reduced costs, increased energy efficiency, and more use of renewables. This in turn could be linked to the: • Renovation Wave initiative • Energy Efficiency Directive • Renewable Energy Directive • Energy Performance of Buildings Directive • Effort Sharing Regulation
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	• Reducing energy poverty is not seen as one clear objective and will depend on the projects selected • It is expected that the programme will have positive environmental benefits
Lessons learned	• Strengths – BIM helps people understand the added value of digital technology and of working in collaborative platforms – People are increasingly working in a consistent manner, following a standard – Good information management increases productivity and reduces the likelihood of problems on projects. This reduces time delays, cost overruns and disputes. • Weaknesses – Adoption rate is still low – Lack of manufacturers to provide the digital objects • Opportunities – An increasing proportion of the workforce are now digital natives – Further develop the tools – Market the successes • Threats – BIM is not understood nor accessible for SMEs – Reluctance from the sector to embark (attitude) – Lack of sharing the benefits to the client
Synergies	
Bibliography	https://plan-bim-2022.fr https://www.thenbs.com/knowledge/10-things-weve-learnt-from-the-2020-bim-survey

3.2 Spain – Improving, standardising and strengthening data collection of the building stock

Policy/initiative	Improving, standardising and strengthening data collection about the building stock in Navarra
Location	Spain (Navarra)
Start year	2014
Status	Ongoing
Building types	Public and private
Type of policy	• Improving, standardising and strengthening data collection about the building stock • Focusing on the measurements and control of energy expenditure in local entities • Developing energy service contracting
Short description	The Navarra 2030 energy plan: • Encourages the hiring of energy service companies in sectors with the greatest potential (both public and private) • Develops procurement procedures and contract models • Sets up a support framework for possible financing
Primary energy savings	• Impact varies across the projects. Projects mainly in the health sector (one clinic, one hospital) and the administration (public council)
CO_2 emission savings	• Impact varies across the projects. Projects mainly in the health sector (one clinic, one hospital) and the administration (public council)
Costs	Range between €200k and €500k yearly savings
Increased renovation rate and depth	• ESCO contracting facilitates renovation in the identified cases • IPMVP as a facilitating factor
Ease of implementation	• Medium
Matching EU policy framework	• The programme and its objectives will contribute to increased renovation rate and speed, reduced costs, increased energy efficiency, and more use of renewables. This in turn could be linked to the: – Renovation Wave initiative – Energy Efficiency Directive – Renewable Energy Directive – Energy Performance of Buildings Directive – Effort Sharing Regulation
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings	• Reducing energy poverty is not seen as a clear objective and will depend on the projects selected • It is expected that the programme will have positive environmental benefits

• Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	
Lessons learned	• Strengths – Improves the centralised energy data management (development of the ICEGONA software) – Concrete projects realised – Development of energy services contracting that coordinates the different actors – Use of the IPMVP standard • Weaknesses – Scale – Access to financing – Lack of formation • Opportunities • Threats – Administrative burden
Synergies	
Bibliography	https://www.navarra.es/NR/rdonlyres/ED666B3E-1CFA-4027-BCBA-B075B2183C6E/306536/PEN2020.pdf https://www.navarra.es/NR/rdonlyres/39C6C3D7-0FC3-4AA2-993E-53D4C7DE6BE7/386924/ICEGONA_InformeFaseI.pdf

3.3 *Denmark – Denmark energy agreement*

Policy/initiative	"Denmark energy agreement" with a focus on renewable energy, energy efficiency improvements, research and energy regulation
Location	Denmark national/regional/municipal level
Start year	Agreement in June 2018
Status	Ongoing
Building types	
Type of policy	Grant, capacity, multi-sector multi-year policy and investment framework toward 2020 and 2050
Short description	The government has decided an "energy agreement" to further build Denmark's international positions of strength with a focus on renewable energy, energy efficiency improvements, research and energy regulation. This agreement is very comprehensive and touches on a lot of issues, including "a smart and flexible energy system" in order to support an integrated, market-based and flexible energy system, with efficient energy utilisation across the electricity, heating and gas sectors, and with a continued strong security of supply. Initiatives in focus include the testing of regulatory free zones and improved use of data and digitisation in the utility sectors. Cross-energy flexibility is particularly important and such initiatives must be replicated. Key elements of the agreement include a commitment to build three new large offshore wind farms, new funding for onshore wind and solar power, a targeted effort to achieve energy savings and a targeted strengthening of energy and climate research.
Primary energy savings	The energy agreement includes the following initiatives: • By 2030, three offshore wind farms will be created for a total of 2400 MW. • The agreement will enable renewable energy to fully cover Denmark's electricity consumption by 2030. • Modernisation of the heating sector, resulting in green and cheap heating for businesses and consumers. • Funds are allocated to manage the abolition of the "basic financial contribution" and to improve the use of surplus heat and the export of energy technologies. • Phasing out coal in Danish electricity generation by 2030.
CO_2 emission savings	• With this agreement, Denmark is on track to fulfil the government's objective of transforming Denmark to a low-carbon society that is independent of fossil fuels by 2050. • The measures combined are estimated to reduce carbon dioxide emissions by 34% by 2020.
Costs	• € 564 million is allocated to a tendering process, where different technologies can compete to provide green electricity at the lowest price. • More than €537 million is allocated to develop green biogas production. A share is reserved for organic biogas. • From 2021 to 2024, €67 million will be allocated annually to a market-oriented and energy-saving subsidy pool, €40 million for industries and €27 million for energy savings in buildings. • A reserve of €54 million in 2025, and then €67 million per year thereafter, will be allocated to further increase the use of renewable energy after 2026. • Immediate easing of taxes on electricity and electric heating, amounting to around €268 million in 2025 (excluding VAT).

	• €67 million is allocated to green transport in 2020-2024 to strengthen mobility and green transport. • Energy and climate research will receive an injection of funds with a target of €134 million per year by 2024.
Increased renovation rate and depth	
Ease of implementation	
Matching EU policy framework	
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	Energy-efficiency measures: with the agreement initiatives, in 2020 Denmark will have reduced its final energy consumption (excluding consumption for transport) by almost 8% compared to 2010. The agreement contains the following elements: • Energy companies must realise specific energy savings exceeding today's requirements, e.g. by consulting energy experts and by offering subsidies to e.g. households and businesses • Energy companies must increase efforts by 75% from 2013 to 2014, and by 100% from 2015 to 2020 compared to 2010-12 • A comprehensive strategy for energy renovation of all Danish buildings will be developed. Green heating measures: • Converting from coal to biomass at large-scale power plants will be made more attractive by amending the Heating Supply Act • Smaller open-field plants that are struggling in the wake of high heating prices will be allowed to produce cheap heating based on biomass • DKK 35 million will be committed to promoting new renewable technologies, e.g. geothermal energy and large heat pumps. Renewable energy in buildings: the agreement supports the phasing-out of oil-fired boilers in existing buildings by: • Banning installation of oil-fired boilers and natural gas boilers in new buildings from 2013 • Banning installation of new oil-fired boilers in existing buildings in areas where district heating or natural gas is available from 2016 • Committing DKK 42 million in 2012-15 to fund the conversion from oil-fired boilers and natural gas boilers in existing buildings to renewable energy. Renewable energy in industry: industry must also convert to a greener energy system, so the agreement lays down that: • A subsidy should be given to help promote investment in efficient use of renewable energy in the production processes of enterprises. In the period 2014 to 2020, the subsidy will be increased to DKK 500 million a year from DKK 250 million in 2013. • Funding of DKK 30 million per year from 2013 to 2020 will be introduced to maintain and promote industrial combined heat and power (CHP) in industries and greenhouses.
Lessons learned	

Synergies	
Bibliography	Description by the ministry of foreign affairs for investors https://investindk.com/insights/new-ambitious-danish-energy-agreement The Danish energy model https://ens.dk/sites/ens.dk/files/Globalcooperation/the_danish_energy_model.pdf IEA Danish Energy Agreement https://www.iea.org/policies/606-danish-energy-agreement-for-2012-2020

3.4 Germany – Digitalisation of the Energy Transition Act

Policy/initiative	Optimise energy use through automation and self-regulation - Digitisation of the Energy Transition Act ('Gesetz fur digitalisierung der EnergieWende')
Location	Germany national/regional/municipal level
Start year	2016
Status	ongoing
Building types	
Type of policy	
Short description	Smart meters will become mandatory, implementation will take place in stages The basis for the roll-out is a market declaration by the Federal Office for Information Security (BSI). A large-scale roll-out is expected from 2020. • Customers with a consumption of over 10,000 kWh per year should be converted from 2017 • Customers with a consumption of less than 10,000 kWh will be converted from 2020 • An intelligent electricity meter is optional for households with a consumption of less than 6,000 kWh - however, a modern meter must be installed This policy in Germany also supports optimal energy use through automation and self-regulation. The aim of the federal funding for the pilot programme for energy-saving meters is to make the trend towards digitalisation also useful for energy efficiency. To this end, companies that help their end customers to save electricity, oil, gas, biomass, heating, cooling or primary energy by means of innovative digital solutions will receive funding of up to €2 million. The aim is to test various technologies with different user groups and bring them to market maturity. With the law on the digitisation of the energy transition, the federal government laid the foundation for intelligent electricity meters. The core element is the Metering Point Operation Act. This law regulates how and when the previous analogue electricity meters are replaced by intelligent measuring systems or modern measuring devices.
Primary energy savings	Germany has set itself ambitious goals with the energy transition. The goals in numbers: • Share of renewable energies in electricity consumption by 2025: 40-45% • Shutdown of the last nuclear power plants by 2022 • 40% less greenhouse gas emissions by 2020 (compared to 1990) • 50% less primary energy consumption by 2050 (compared to 2008) In order to achieve the goals, electricity from wind and sun is particularly important but is not based on the demand for power. The greater the proportion of electricity from renewable sources, the greater the challenge of balancing the production and consumption of electricity. This is where the new digital electricity meters systems and modern measuring devices help.
CO_2 emission savings	

Costs	Overall investment: Approx. €10-20 bn.
Increased renovation rate and depth	
Ease of implementation	
Matching EU policy framework	
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	• **Increase smart readiness of buildings**: Smart meters support the energy transition, digitisation and controllability within the power grid. • **Energy poverty**: The intelligent electricity meters enable the possibility of creating variable electricity tariffs or the cost savings that result from the fact that intelligent measuring systems do not have to be read on-site. • **Fair transition** • **Consumer advantages:** Visualisation of power consumption almost in real time; better cost control and overview; identification of power guzzlers; avoidance of back payments for electricity; reduction of power consumption; use of time-variable electricity tariffs; remote meter reading; better transparency – comparison of own consumption with the average
Lessons learned	• In January 2019, the first barometer on the digitisation of the energy transition for the 2018 reporting year was published. The second barometer describes considerable efforts and progress made in implementing the “Law on the Digitization of the Energy Transition”. The smart meter rollout after the third certification of a smart meter gateway and the publication of the market declaration by the Federal Office for Information Security at the end of January 2020 were positively highlighted. • An important task for 2019 was updating the legal framework for the network-oriented control of flexible consumer devices according to § 14a EnWG (German Energy Law). The decision to use the 450 MHz frequencies for the digitisation of the energy industry is also considered a critical success factor. • Ultimately, the end customers need to be more closely informed and involved.
Synergies	

Bibliography	Legal text (DE): https://www.bmwi.de/Redaktion/DE/Downloads/Gesetz/gesetz-zur-digitalisierung-der-energiewende.pdf?__blob=publicationFile&v=4 EON https://www.eon.de/de/eonerleben/smart-meter-pflicht-in-deutschland.html EY Barometer https://www.bmwi.de/Redaktion/DE/Artikel/Energie/gutachten-digitalisierung-der-energiewende.html PwC https://www.pwc.de/de/energiewirtschaft/Studie_Digitalisierung_und_Energiewende.pdf

4 GOOD PRACTICE EXAMPLES: FINANCING RENOVATION

The following pages provide examples of good practice policies in the strategic area of *financing renovation.*

4.1 Croatia – Methods to make energy renovation attractive

Policy/initiative	Methods of making energy renovation investments more attractive to banks and private investors
Location	Croatia
Scope	National
Start year	2014
Building types	Public buildings and residential buildings
Status	Ongoing
Type of policy	De-risking energy efficiency investments with the help of public financing
Short description	Financial and regulatory mechanisms aimed at mobilising private investment into strategic renovation of the national building stock by making it more attractive: • By establishing a national revolving fund by means of redeploying resources from ESI funds[1], energy service providers will be enabled to access a long-term funding source at more favourable market conditions, and banks will be enabled to place resources through the fund. • By introducing special guarantee instruments, the risk factor of private investor funds placement will be reduced. • Subsidising the interest rates on commercial loans will enable commercial banks to finance building energy renovation. • Promoting the development of the energy service market through the implementation of the programme of renovation of public buildings. • Developing standard energy performance contracts and standardised methods for measuring and verifying energy savings that will enhance the trust of users and financial institutions in the ESCO model.
Primary energy savings	The energy renovation of public buildings programme (2014-2015) covered 69 buildings with active contracts, saving a potential 70 GWh of energy annually. About 55% of delivered energy savings have been achieved. The energy renovation programme for public sector buildings 2016-2020, co-financed through the allocation of grants from ESI funds, aims to save about 50 GWh/year and to reduce energy consumption by up to 70%. The 2014-2020 multi-residential buildings energy renovation programme was expected to deliver on average 66% energy savings.
CO_2 emission savings	No data available
Increased renovation rate and depth	The energy renovation of public buildings (2014-2015) covered an area of 257,000 m^2 of 69 buildings.

[1] The European Structural and Investment Funds (ESIF) comprise the European Regional Development Fund (ERDF), the Cohesion Fund (CF), the European Agricultural Fund for Rural Development (EAFRD), the European Social Fund (ESF), and the European Maritime and Fisheries Fund (EMFF).

	The 2014-2020 multi-residential building energy renovation programme had 2,355 applications approved in two years. The 2014-2020 family houses energy renovation programme has 15,000 projects.
Synergies	**Engaging transformation and phasing out inefficient buildings**: This measure helps to tackle renovations with long pay-back periods, enabling the implementation of less cost-effective measures. **District approach:** This measure assesses multi-building renovations, hence streamlining and aggregating renovation solutions.
Bibliography	Ministry of Construction and Physical Planning (2017). Proposal of the Long-Term Strategy for Mobilising Investment in Renovation of the National Building Stock of the Republic of Croatia. https://ec.europa.eu/energy/sites/ener/files/documents/lts_croatia_2017.pdf Ministry of Construction and Physical Planning (2017). *Energy renovation of buildings in Croatia.* https://ec.europa.eu/energy/sites/ener/files/documents/006_kriz_selendic_seif_milan_16-11-17.pdf

4.2 *The Netherlands – Tenants' right to initiate deep renovations*

Policy/initiative	Lange Termijn Renovatiestrategie | Long-Term Renovation Strategy / Tenants' right to initiate deep renovations
Location	The Netherlands
Scope	National
Start year	To be determined
Building types	Residential (rented homes)
Status	In research
Type of policy	Regulation
Short description	Under the regulation in force, at least 70% of the tenants must agree to a renovation of a complex. The civil code already offers a solution for certain cases in which the tenant requests energy saving measures, and the landlord is obligated to carry out and pay for these investments providing the tenant is prepared to accept an increase in the rent. Since minimum standards will become mandatory in 2050 for all rented homes, government is currently assessing whether rules should be amended to allow tenants to require landlords to carry out a deep renovation of the house and whether these standards and 2050 target values can play a role in a possible adjustment.
Primary energy savings	This initiative is still under review. There are no estimations available on the primary energy savings this initiative would have.
CO_2 emission savings	This initiative is still under review. There are no estimations available on the CO_2 emission savings this initiative would have.
Increased renovation rate and depth	Over 40% of homes in The Netherlands are rented. This represents 3 million rental homes. Minimum sustainability standards will be mandatory for all rented homes by 2050.
Synergies	**Engaging transformation and phasing out inefficient buildings**: The proposoal to change the civil code to enable tenants to obligate landlords to make certain improvements would address the split-incentive dilemma by achieving deep energy renovation in an heterogenous building stock with mixed ownership.
Bibliography	Netherlands Enterprise Agency. (2020, March). *Long term renovation strategy.* https://ec.europa.eu/energy/sites/ener/files/documents/nl_2020_ltrs_en.pdf *Rented housing*. Government.nl. (2020). Retrieved 11 August 2020, from https://www.government.nl/topics/housing/rented-housing.

4.3 USA – Property Assessed Clean Energy (PACE)

Policy/initiative	Property Assessed Clean Energy (PACE)
Location	USA
Scope	Regional
Start year	2008
Building types	Residential and commercial
Status	Ongoing
Type of policy	On-tax financing
Short description	Property Assessed Clean Energy (PACE) is a way to finance a wide range of energy and water efficiency, renewable energy, and hazard mitigation improvements permanently attached to residential (R-PACE) and commercial (C-PACE) properties. Established by state statutes and enabled by local governments, PACE financing is structured as an assessment against the property and not the property owner. PACE provides 100% of the cost of qualified structural improvements, which the property owner repays annually or semi-annually through a special assessment added to the property tax bill. The average repayment period is typically over 10 to 20 years through property assessments, which are secured by the property itself and paid as an addition to the owner's property tax bills. Typical home improvement projects include replacement of broken or failing heating and cooling systems and hot water heaters; air sealing and insulation; ENERGY STAR doors, windows, roofing; ENERGY STAR appliances; solar photovoltaic systems; and water conservation and resiliency measures (e.g., seismic retrofits and wind hazard protection). Non-payment generally results in the same set of repercussions as the failure to pay any other portion of a property tax bill.
Primary energy savings	Cumulative energy saved (kWh) (2009 - 2019)[2] • C-PACE: 7,929,319,000 • R-PACE: 21,811,465,000 • Total: 29.754 billion
CO_2 emission savings	Total carbon abated (metric tonnes) (2009 – 2019)[3] • C-PACE: 2,850,000 • R-PACE: 4,587,000 • Total: 7,44 million
Increased renovation rate and depth	Through 2019, 37 states and Washington D.C. have passed PACE-enabling legislation, 22 states and Washington D.C. have active C-PACE and 3 states have active R-PACE (California, Florida and Missouri). In 2019, C-PACE: • Surpassed US$1.5 billion cumulative investment on 2,400 buildings • Created 18,000 jobs • Reached US$670 million annual investment equal to 150% growth over 2018

[2] Impacts are estimated over useful lifetime of installed measures. Includes data reported to PACENation as of April 1st, 2020.
[3] Impacts are estimated over useful lifetime of installed measures. Includes data reported to PACENation as of April 1st, 2020.

	• Investment by project type: 49% energy efficiency, 23% renewable energy, 7% resiliency and 22% mixed-projects. • The building type most invested was hospitality (US$161.3 million), followed by office (US$128.7 million) and retail (US$93.3 million) • 14% of the investment was in new construction. In 2019, R-PACE: • Surpassed US$6.2 billion cumulative investment on over 280,000 homes. • Created 108,000 jobs. • Was poised for growth in 2020 with programmes in development in Ohio and New York. • Exceeded US$650 million in cumulative investment for hurricane resiliency and seismic strengthening • Investment by project type: 70% energy and water efficiency, 21% renewable energy and 9% resiliency.
Ease of implementation	The financing model was launched in California in 2008 and has been successfully carried out in the United States for several years. In the past four years, the PACE market reached over US$4.7 billion in funded projects nationwide, including the retrofit of over 200,000 homes, which resulted in more than 42,000 new local jobs and the creation of hundreds of new companies. C-PACE programmes exist in several states, regions and local governments. Programmes vary across several dimensions including the level of organisation (statewide vs. local programmes), financing structures, and eligible measures. More than 35 states plus the District of Columbia have C-PACE enabling legislation and more than US$800 million in projects have been financed. PACE programmes are typically enabled through state legislation and authorised at the local government level. Municipalities may administer residential PACE programmes directly, or through public-private partnerships with one or more PACE providers. Unlike C-PACE programmes, which have been broadly adopted and launched across dozens of states and thousands of municipalities but funded a smaller volume of projects, R-PACE has experienced challenges due to concerns raised by the mortgage banking industry and consumer advocates. The degree of transferability across countries is considered as medium, since internal regulation of each country must allow this scheme. The fact of municipalities or local governments acting as a capital provider might be conflictive in certain countries.
Matching EU policy framework	This measure could be included in the national long-term renovation strategies of the EU countries, which are an obligation under the Energy Efficiency Directive (2012/27/EU), as it is a policy that stimulates cost-effective deep renovation of buildings and targets the split-incentive dilemma and energy poverty. It could also fit in the Renovation Wave initiative because it promotes energy efficiency investments in buildings. It would fit the clean energy for all Europeans package as this proposition is in line with the commitment to tackle energy poverty and protect vulnerable consumers.
Costs	No data available

Objectives tackled	**Secure fair transition**: By putting the burden of the loan on the building rather than on the person, it allows for certain groups who may have difficulty accessing credit, such as low-income people and the elderly, to do the necessary work. **Energy poverty:** Innovative financing instrument to upgrade residential properties and lower energy bills for vulnerable populations. **Improve health and wellbeing**: Typical home improvement projects might include replacement of broken or failing heating and cooling systems and hot water heaters; air sealing and insulation; ENERGY STAR doors, windows, roofing; ENERGY STAR appliances; solar photovoltaic systems; and water conservation and resiliency measures (e.g., seismic retrofits and wind hazard protection), improving the indoor environmental quality. **Increased sustainable infrastructure in built environment***:* Studies demonstrate that renovations under the programme reduce vulnerability to earthquakes and hurricanes.
Lessons learned	Success factors, strength and opportunities • Allows for secure financing of comprehensive projects over a longer term, making more projects cash-flow positive. • Spreads repayment over many years, seldom requires an upfront payment, and removes the requirement that the debt be paid at sale or refinance. • Can lead to low interest rates because of the high security of loan repayments attached to the property tax bill. • Helps some property owners deduct payments from their income tax liability. • Allows municipalities to encourage energy efficiency and renewable energy without putting general funds at risk. • Taps into large sources of private capital. • Direct benefits such as reduction in electricity and natural gas use, increase in renewable electricity generation, reduction in the emission of greenhouse gases, reduction in water use and reduction in vulnerability to earthquakes and hurricanes. • Co-benefits include increase in business sales revenue, GDP, personal income and employment, increase in tax revenues for various levels of government, reduction in property damage, reduction in disaster relocation cost and reduction in hazard insurance premiums. Challenges of implementation (weaknesses and threats) • Available only to property owners. • Cannot finance portable items (screw-in light bulbs, standard refrigerators, etc.). • Can require dedicated local government staff time. • May require high legal and administrative setup obligations. • Not appropriate for investments below US$2,500. • Potential resistance by lenders/mortgage-holders whose claims to the property may be subordinated to the unpaid assessment amount should the property go into foreclosure. • Uncertainty about the likelihood of tax foreclosure on properties in default of C-PACE payments and the risks local governments bear. • Uncertainty about the staff labour commitment associated with administering the programme, including the execution of the special tax assessment process.

Synergies	**Health and wellbeing:** It has potential to improve health and wellbeing as typical home improvement projects might include replacement of broken or failing heating and cooling systems and hot water heaters; air sealing and insulation; ENERGY STAR doors, windows, roofing; ENERGY STAR appliances; solar photovoltaic systems; and water conservation and resiliency measures (e.g., seismic retrofits and wind hazard protection), improving the indoor environmental quality. **Engaging transformation and phasing out inefficient buildings**: By putting the burden of the loan on the building rather than on the person, it allows for certain groups who may have difficulty accessing credit, such as low-income people and the elderly, to do the necessary work. In addition, it could tackle energy poverty by potentially lowering energy bills for vulnerable populations. **Built environment sustainability and adaptation to climate change**: Among its direct benefits we can find reduction in vulnerability to earthquakes and hurricanes and reduction in water, electricity and natural gas use.
Bibliography	*Property Assessed Clean Energy Programs*. https://www.energy.gov/. (2020). Retrieved 7 August 2020, from https://www.energy.gov/eere/slsc/property-assessed-clean-energy-programs. Rose, A., & Wei, D. (2019). Impacts of the Property Assessed Clean Energy (PACE) Program on the Economies of California and Florida. http://www.schwarzeneggerinstitute.com/images/files/SI_White_Paper%20PACE_Economic_Impacts_FINAL_3_6_19.pdf PACENation. (2019). *PACE Facts*. https://pacenation.org/wp-content/uploads/2020/04/PACE-Facts-4-24-20.pdf *PACE Market Data* | *PACENation*. PACENation. (2020). Retrieved 10 August 2020, from https://pacenation.org/pace-market-data.

4.4 Germany – KfW Energy Efficiency Programme

Policy/initiative	KfW energy efficiency programme - Energy-efficient renovation investment subsidy
Location	Germany
Scope	National
Start year	2007
Building types	Residential houses and condominiums (must be primary residences)
Status	Ongoing
Type of policy	Loan programme
Short description	This programme serves to promote comprehensive refurbishment into "KfW efficiency houses" or individual measures to improve energy efficiency. As well as repayment bonuses dependent on the primary energy consumption of the efficiency house, a special promotion is possible if construction is supervised by an external technical expert. Through the loan, applicants can receive an investment subsidy that depends on the energy standard achieved: • KfW Efficiency House 55: up to €48,000 (40% of a maximum of €120,000 of eligible costs per residential unit) • KfW Efficiency House 70: up to €42,000 euros (35% of a maximum of €120,000 of eligible costs per residential unit) • KfW Efficiency House 85: up to €36,000 (30% of a maximum of €120,000 of eligible costs per residential unit) • KfW Efficiency House 100: up to €33,000 euros (27.5% of a maximum of €120,000 of eligible costs per residential unit) • KfW Efficiency House 115 and Monument: up to €30,000 (25% of a maximum of €120,000 of eligible costs per residential unit) • Individual measures: up to €10,000 (20% of a maximum of €50,000 of eligible costs per residential unit). These include thermal insulation of walls, roof surfaces, basement and storey ceilings, renewal of the windows and external doors, connection to local or district heating, optimisation of an existing heating system and the renewal or installation of a ventilation system
Primary energy savings	The energy-efficient renovation investment subsidies are a part of the KfW's "energy-efficient refurbishment" programme. In terms of energy conservation, the energy use in newly retrofitted buildings has decreased from approximately 120 kWh per square metre per year to 80 kWh/m^2/yr.
CO_2 emission savings	The energy-efficiency measures supported by the programmes are helping to reduce carbon emissions by almost 9 million tonnes per year.
Increased renovation rate and depth	Overall, KfW's promotional funding has triggered investments of over €260 billion in building measures and secured an average of 320,000 jobs per year in the building industry and regional trades. Every second newly built home in Germany is currently supported by funds from the "energy-efficient construction" programme and close to 290,000 homes received an energy-efficient makeover with the help of KfW in 2016.
Ease of implementation	Steps to obtain funding: 1. Hire experts for energy efficiency: Energy-efficient renovation requires complex specialist knowledge. An energy efficiency expert ensures that the construction work leads to the desired result. All experts who are included in the expert list of the German Energy Agency (dena) for federal funding programmes are admitted.

	2. Applicants can combine funding opportunities: combine further funding and at the same time remove barriers during the renovation. 3. Invesment grant application: before works start or the purchase contract is signed, applicants must submit their application directly in the KfW grant portal. 4. Proof of identity: applicants must give proof of their identity once the grant has been awarded 5. Finalisation: once the project has been finalised the applicant, together with the expert must fill out the "confirmation after implementation" form, after which the investment grant will be paid. The degree of transferability across countries is considered high.
Matching EU policy framework	Could match and be used to meet the requirements established in the Energy Performance of Buildings Directive. National Energy Efficiency Funds, which are set by the Directive 2012/27 Could also be part of the Renovation Wave initiative, allocating specific funds to guarantee this type of financing
Costs	The German Ministry for Economic Affairs and Energy (BMWi) currently issues over €2 billion a year for the programmes, which form part of the campaign "efficiency first". KfW commitments amount to around €70-80 billion p.a
Objectives tackled	**Increased sustainable infrastructure in the built environment***:* Owners of dwellings are able to implement energy efficiency measures, financing their investments through the loans. As a result, the housing stock in Germany is more sustainable. **Improved health and wellbeing**: The implementation of the energy efficiency measures covered by the programme also increases both the wellbeing and the health of the residents, as they have better thermal conditions and better insulation, among others.
Lessons learned	Success factors, strengths, and opportunities • Provides low-interest and long-term financing of investments designed to save energy and reduce CO_2 in the residential building stock, new buildings and buildings that form part of the municipal and social infrastructure • Different grants and loans can be combined by applicants to obtain more beneficial conditions • The incentives designed both to internalise external effects in the field of climate protection and to promote energy efficiency are accompanied by a positive impact on employment and surplus government revenues • Stability and attractiveness of promotional product offer – established brand (KfW Efficiency House) Challenges of implementation (weaknesses and threats) • Lack of public awareness • High budgetary need • Monitoring of effects can be quite challenging and bureaucratic procedures can become complicated • Assuring target-oriented use of public funds needs to be closely monitored
Synergies	**Engaging transformation and phasing out inefficient buildings**: Longer payback periods are available with low monthly repayments, enabling the implementation of less cost-effective measures. **Health and well-being**: Associated with renovations that improve the health, comfort and air quality of the occupants, such as thermal comfort and better insulation.

Bibliography	"Ten Years of the KfW's 'Energy-Efficient Construction and Refurbishment' Programmes." *KfW Bankengruppe*, www.kfw.de/KfW-Group/Newsroom/Latest-News/Pressemitteilungen-Details_403200.html *Energieeffizient Sanieren – Investitionszuschuss (430)*, www.kfw.de/inlandsfoerderung/Privatpersonen/Bestandsimmobilien/Finanzierungsangebote/Energieeffizient-Sanieren-Zuschuss-(430) Dorendorf, Bettina. "KfW Promotional Programs for Energy Efficiency in Buildings." *EC*, European Comission, 2018, ec.europa.eu/energy/sites/ener/files/documents/08_housing_bettina_dorendorf_kfw.pdf

4.5 France – the Denormandie law

Policy/initiative	The Denormandie law
Location	France
Scope	National
Start year	2019
Building types	Residential
Status	Ongoing
Type of policy	Tax rebate – Regulatory measure
Short description	The Denormandie law aims to renovate dilapidated housing in some French cities through an advantageous tax exemption programme for investors. The level of tax reduction that it grants ranges from 12 to 21% depending on the rental period of the renovated property (6.9 or 12 years). Renovation work should: • Improve the energy performance of housing by at least 30% (20% in collective housing) • Represent two types of work from a choice of five: – Roof insulation – Change of boiler – Wall insulation – Window insulation – Change in hot water production
Primary energy savings	No data available
CO_2 emission savings	No data available
Increased renovation rate and depth	In territories that have a large old park resulting in major investment needs, the effects of the tax benefits introduced by the Denormandie amendment would increase real estate yields by 5-8% gross, according to simulations carried out by the National Real Estate Federation (FNAIM).
Ease of implementation	Complements the existing system, the Pinel law. The Denormandie is valid until December 31, 2022. To benefit from the Denormandie law, the investor must be a taxpayer domiciled in France: the acquisition can be made by a natural person, via an SCI (Société Civile Immobilière)[4] or in joint ownership (in the case of SCI or joint ownership, the tax reduction is made in proportion to the shares). The tax reduction is not applicable to dwellings whose property rights have been dismembered (dissociation between ownership and enjoyment). The investor must buy old housing that does not meet the legal criteria for decent housing. The property must be located in one of the 222 municipalities targeted by the City Heart Action plan or in those which are the subject of a regional revitalisation operation. In short, the acquired housing is not yet habitable and is located in a district to be rehabilitated.

[4] Société Civile Immobilière (SCI) a rather specialist type of French company (société) that is constituted for the ownership and management of property (immobilière).The fact that it is also "civile" means that it is a non-trading company, thereby distinguishing it from a company set up to pursue commercial objectives.

	The amount of the renovation work must represent at least 25% of the total value of the transaction. These works concern both energy renovation, improving energy performance by at least 30% for a house and 20% for apartments, as well as modernisation, sanitation, development of living areas (attics and basements) and creation of new living space. To redo the accommodation, applicants must go through a company. As with all tax exemption operations, they must be able to provide supporting documents to the tax authorities if they request it. The conditions are strict and will be checked. Applicants may not do the work themselves but must go through a certified tradesperson RGE (recognized guarantor of the environment). The property must have an energy consumption of less than 331kWh per square metre per year at the end of the work. In addition to the invoices, it will also be necessary to carry out an energy performance diagnosis before and after in order to prove the evolution. The degree of transferability could be considered as high.
Matching EU policy framework	This measure would fit in the national long-term renovation strategies, which are a requirement for EU countries under the EPBD (2018/844/EU) Article 2 bis, because it supports the transition into a highly energy efficient building stock and targets the split-incentive dilemma. It could also fit in the Renovation Wave initiative because it promotes energy efficiency investments in buildings. It would fit the clean energy for all Europeans package as this measure is in line with the commitment to tackle energy poverty and protect vulnerable consumers.
Costs	To benefit from this, the amount of the invoice for the energy renovation works must be equal to or greater than 25% of the price of the property. The amount of the tax benefit is determined on the basis of a double price ceiling: €5,500/m² without being able to exceed €300,000. If the total amount of the project reaches €350,000 and does not exceed €5,500/m², for example, the tax exemption would be calculated on €300,000. In addition to the tax reduction, the taxpayer can deduct from their overall income within the limit of €10,700 the following elements: • The property tax, management or management fees, loan insurance. • Insurance premiums • Guaranteed rents (guarantee of rental vacancy and guarantee of unpaid rents) • The charges borne by the owner (fees of the building manager). Only loan interest is not deductible from overall income; however, this can be carried over for 10 years.
Objectives tackled	**Energy poverty:** It can help to alleviate energy poverty, restoring property in poor condition and addressing the split-incentive dilemma. **Improve health and wellbeing**: The possible actions (wall insulation, attic insulation, window insulation, heating, hot water production) support indoor environmental quality. **Upgrade of urban context**: The buildings renovated are located in the centre of one of the 245 municipalities participating in the "Cœur de Ville" operation. Furthermore, the system extends to rural areas. **Secure fair transition**: Tenants must have incomes below certain thresholds. It will be necessary to rent to a person who has modest income, as goods to be rented are reserved for low-income households.

Lessons learned	Success factors, strength and opportunities • The main advantage of the Denormandie law is the fact that it allows tax exemption of up to 21% of the price of the property purchased if it is rented for 12 years. This will act as an incentive for the renovation of rented properties, tackling the split-incentive dilemma. It is aimed at a large panel who want to both reduce their taxes and build up assets. • Older homes are located in the heart of cities, so they are often better placed than newer homes. It encourages investment in city centres where there are few new real estates offers and very often at lower prices than new real estate. • The acquisition is faster – even with the work to be carried out it takes on average four months to start renting the property, compared to two months for a new property. • The system extends to rural areas. Challenges of implementation (weaknesses and threats) • Investors cannot deduct 25% of works from their rents to create a land deficit, as specified in paragraph F of article 199 novovicies of the General Tax Code (CGI). A land deficit is created when the expenses are greater than the income. It is impossible to benefit from the tax reduction on works and in addition to deductg them from the rents during the tax return. • If, in the same year, the reduction obtained is greater than the tax payable, the excess cannot be carried forward. The reduction is imputable to the tax for the year of completion of the works regardless of the month of this completion, or to the tax for the year of acquisition if this is later. • Not all the municipalities eligible for the Denormandie law have the same appeal for a real estate investor. Investores must first and foremost be interested in the rental market and prospects and not focus solely on tax exemption. • The Denormandie law is subject to a certain number of constraints (price ceiling per m², rent ceiling, tenant income ceiling); it will be necessary, depending on each type of investment, to measure the weight of these constraints and to verify that they remain acceptable • Another disadvantage of renting under the Denormandie law is the obligation to set a ceiling rent in advance. This means that if your rent exceeds the authorised ceiling, you will not be able to benefit from the tax reduction. The rent ceiling must be calculated each time a lease is signed and the ceiling changes every year.
Synergies	**Engaging transformation and phasing out inefficient buildings**: It can help to create an enabling framework for deep renovations that are not cost-effective and to increase the rate of deep renovations. **Health and well-being***:* The possible actions (wall insulation, attic insulation, window insulation, heating, hot water production) support indoor environmental quality
Bibliography	Loi Denormandie : conseils défiscalisation Denormandie » K&P Finance. K&P Finance. (2020). Retrieved 7 August 2020, from https://www.kp-finance.com/conseils/defiscalisation-immobiliere/loi-denormandie/. Chevillard, P. (2020). Défiscaliser avec le Denormandie dans l’ancien - PAP.fr. Pap.fr. Retrieved 7 August 2020, from https://www.pap.fr/bailleur/choisir-investissement/la-fiscalite-immobiliere/a1247/defiscaliser-avec-le-denormandie-dans-l-ancien. Loi Denormandie 2020 ⇒ Investir dans l'ancien : Communes éligibles - Plafonds - Travaux de rénovation pour défiscaliser en loi Pinel ancien. Loi

	de Normandie. (2020). Retrieved 7 August 2020, from https://www.loi-de-normandie.fr/. Loi DENORMANDIE => De quoi s'agit-il et Comment ça fonctionne?. Corrige ton impôt. (2020). Retrieved 7 August 2020, from https://www.corrigetonimpot.fr/loi-denormandie-impot/. www.budget.gouv.fr/documentation/file-download/6982

4.6 *Italy – Ecobonus / Superbonus*

Policy/initiative	Ecobonus/ Superbonus
Location	Italy
Scope	National
Start year	2020
Building types	Applies to residential, non-residential and mixed buildings
Status	Ongoing
Type of policy	Tax rebate
Short description	Ecobonus Deduction for energy saving works carried out both on single buildings and in condominiums. It is possible to access a tax deduction from 50 to 65% for works on single buildings, which rises up to 75% for expenses for energy requalification interventions in condominiums. The deduction for interventions on housing concerns all interventions and expenses incurred for the purpose of: • Thermal improvement of the building (insulation, floors, windows and fixtures) • Installation of solar panels • Replacement of winter air conditioning systems • Home automation, e.g. installation of multimedia devices for remote control of heating systems. Superbonus The Superbonus is a subsidy provided by the Relaunch Decree which raises to 110% the rate of deduction of expenses incurred from 1 July 2020 to 31 December 2021 , for specific interventions in the field of energy efficiency, anti-seismic interventions, installation of photovoltaic systems or infrastructure for charging electric vehicles in buildings. Individuals can convert the ordinary tax credits connected with qualified building renovation and energy efficiency costs incurred during 2020 and 2021 into: (a) a transferable tax credit; or (b) a discount of the relevant cost applied by the service provider (in such case, the transferable tax credit is granted to the service provider). The tax credit cannot be refunded or carried forward to subsequent fiscal years. It will be recognised exclusively for those jobs that guarantee the highest energy saving performance (improvement of at least two building energy classes): • Thermal insulation of vertical and horizontal opaque surfaces affecting the building envelope with an incidence greater than 25% of the gross dispersing surface of the building itself • The replacement of winter air-conditioning systems on common parts of buildings and on single-family buildings. As an alternative to the direct use of the deduction, it is possible to opt for an advance contribution in the form of a discount from the suppliers of the goods or services (discount on the invoice) or for the assignment of the credit corresponding to the deduction due. The assignment can be ordered in favour of: • Suppliers of goods and services necessary for the implementation of interventions • Other subjects (natural persons, also performing self-employed or business activities, companies and entities)

	• Credit institutions and financial intermediaries. The subjects who receive the credit have, in turn, the faculty of assignment.
Primary energy savings	In terms of energy savings achieved in 2017 by technology, the main contribution derives from the replacement of windows and shutters (584 GWh/year on over 1,300), while over a quarter of savings was achieved thanks to interventions on walls, slabs and roofs (about 350 GWh/year). In total, by 2017 approximately €3.8 million was invested, saving a total of 1,301 GWh/year of energy. The trend of achieved energy savings is increasing, with 0.112 Mtoe/year in 2017. Energy savings amount to just over 0.4 Mtoe/year in the 2014-2017 period; starting from 2011, the achieved energy savings amount to 0.77 Mtoe/year; total savings are equal to 1.31 Mtoe/year since the scheme started in 2007.
CO_2 emission savings	The savings achieved in 2011-2017 thanks to all the incentive mechanisms including the Ecobonus, prevented the emission of about 19 $MtCO_2$ in 2017, more than 5% of the CO_2 emissions reported for Italy in 2016.
Increased renovation rate and depth	Overall, fiscal incentives and tax deductions for building/energy renovation applied since 1998 have stimulated interventions in 60% of Italian households (in 2017). In terms of investment, almost €32 billion has been spent on the renovation of buildings between 2007 and 2016 With the interventions related to common parts of condominiums, the insulation of the casing with affected surface must be > 25% dispersing surface and interventions related to the facade must influence from the thermal point of view or affecting the plaster for more than 10% of the total dispersing surface of the building.
Ease of implementation	The policy is administered nationally. The beneficiaries of the Ecobonus – all resident and non-resident taxpayers – can deduct the aforementioned intervention costs in their tax declarations. The procedure to benefit from the tax deduction implies specific documentation requirements. It also establishes precise rules regarding invoicing and condominium expenses. First, an affidavit proving that the intervention has been accomplished following the technical requirements. Another required document is an energy certificate, which shall include all data linked to the energy performance of the building. Finally, an information sheet specifying the details of the intervention(s) shall be also included. Within 90 days after the completion of the intervention – starting with the day when the test (collaudo) is carried out and not when the payment is done – this last document, together with a copy of the energy certificate, need to be sent electronically or by certified mail to the National Agency for New Technologies, Energy and Sustainable Economic Development - ENEA. The degree of transferability across EU countries is considered high.
Matching EU policy framework	The Ecobonus contributes to the first objective of the Construction 2020 Action Plan ("Stimulating favourable investment conditions") and also helps to achieve the third objective ("Improving resource-efficiency, environmental performance and business opportunities"). It is also the transposition of the alternative measure under Article 7 of the Energy Efficiency Directive

	It could fit in the European Green Deal, as it will help to achieve the ambitious goal of carbon-neutrality by 2050 by improving the energy efficiency in buildings.
Costs	The tax credits purchased are divided into 5 or 10 equal annual instalments. The maximum deductible limit is: • €100,000 for energy redevelopment interventions • €60,000 for interventions on the building envelope • €30,000 for the replacement of winter air-conditioning systems, or the installation of plants equipped with condensing boilers, high-efficiency heat pumps and low-enthalpy geothermal systems • €60,000 for the installation of solar panels useful for the production of hot water for domestic or industrial use and for covering the need for hot water in swimming pools, sports facilities, shelter and care homes, schools and universities.
Objectives tackled	**Increased smart readiness of buildings***:* Due to the intervention related to building automation systems. **Upgrade of urban context (including access to sustainable mobility):***.* Due to installation of photovoltaic solar systems and the infrastructure for charging electric vehicles.

Lessons learned	Success factors, strength and opportunities:
	• Tax deductions are the most generous system of incentives ever established by the government to promote energy efficiency and sustainable economic development in the Italian construction and real estate sector. The Superbonus can set an example in Europe as a useful tool to promote a green recovery in the building sector, by setting incentives for households and companies.
	• Thanks to these tax advantages and the possibility to transfer tax credits, it is possible to significantly reduce the overall or immediate upfront costs of energy efficiency projects.
	• From a government perspective, the President of the Environmental Commission of the Italian government argues that the Ecobonus qualifies the trade entrepreneurial system and at the same time reduces energy consumption, pollution and household bills.
	• In addition, the increase in the number of interventions over the years proves that citizens are more aware of the benefits of improving the energy performance of their buildings.
	• This will make it easier to achieve the decarbonisation goals for 2030.
	
	Challenges of implementation (weaknesses and threats):
	• This tax incentive is "non-structural", meaning that it is not a stable measure as it needs to be reconfirmed each year.
	• Despite the success of the measure, two problems that the government should take into consideration have been identified:
	  – Firstly, the cost of renovating residential buildings remains considerably higher than the typical levels in the industrial sector, although the savings are the same: the cost-effectiveness ratio of tax deductions and energy bills is up to eight times higher than with the white certificate mechanism.
	  – Secondly, the Ecobonus presumes that families are in possession of sufficient financial means to invest in energy saving renovation, without giving consideration to those families that do not and/or are living in energy poverty.

Synergies	**Built environment sustainability and adaptation to climate change**: the 110% Superbonus will also go to seismic adaptation works (sismabonus). **Digital technology**: With jobs such as home automation, this measure enhances the optimisation of energy use through digitalisation, helping to reap the full benefits of deep renovations. In addition, it unleashes the flexibility potential of energy uses via photovoltaics and storage systems. **Engaging transformation and phasing out inefficient buildings**: Creates an enabling framework for non-economical renovations, or those with a very long payback period, and to advance approaches to take into account wider benefits. **Clean and sustainable mobility**: Additional interventions include infrastructure for charging electric vehicles.
Bibliography	D'Andrea, A. (2020). *Ecobonus 202 0, how does it work? News and energy saving deduction guide*. informazionefiscale.it. Retrieved 4 August 2020, from https://www.informazionefiscale.it/ecobonus-2020-detrazione-risparmio-energetico-come-funziona-spese-limiti-novita. *Ecobonus e Sismabonus 110% | Deloitte Italy | Tax*. Deloitte Italia. (2020). Retrieved 4 August 2020, from https://www2.deloitte.com/ecosismabonus110. EY. (2020). Italy enacts "Relaunch Decree" to further manage COVID-19. https://taxnews.ey.com/news/2020-1365-italy-enacts-relaunch-decree-to-further-manage-covid-19 Ministry of Economic Development. (2020). Annual report on energy efficiency. Results achieved and targets for 2020”. https://ec.europa.eu/energy/sites/ener/files/documents/it_annual_report_eed_2020_tra.pdf *Superbonus 110%*. Agenziaentrate.gov.it. (2020). Retrieved 5 August 2020, from https://www.agenziaentrate.gov.it/portale/superbonus-110%25. European Construction Sector Observatory. (2018). *Policy measures factsheet. Italy. Eco bonus*. https://ec.europa.eu/docsroom/documents/33521/attachments/5/translations/en/renditions/native

5 GOOD PRACTICE EXAMPLES: HEALTH AND WELLBEING

The following pages provide examples of good practice policies in the strategic area of *health and wellbeing.*

5.1 Brussels (Belgium) - Regional Intervention Pollution Unit (CRIPI)

Policy/initiative	Regional Intervention Pollution Unit (CRIPI)
Location	Brussels Capital region, Belgium
Start year	2016 (CRIPI established in 2000)
Status	Ongoing
Building types	Residential buildings
Type of policy	Awareness raising and supportive measure (non-legislative)
Short description	The environmental department of the regional Brussels government established the Regional Intervention Polution Unit (CRIPI) in 2000 in cooperation with PSI/Sciensano (public health research institution) and FARES (Foundation against Respiratory Disorders and for Health Education) to detect indoor pollution in living spaces that might cause health problems. The service is intended to complement a medical diagnosis and identify and quantify indoor pollutants. By monitoring and building a database, CRIPI helps to inform the public and improve indoor environmental quality for Brussels residents [2]. An assessment of the indoor climate is initiated on a doctor’s request and needs the coordination of different actors in the municipality. Tests include indoor and outdoor samplings, measurement of airborne particles, room temperature and relative humidity. The analysis includes advice on user behaviour, ventilation and, if renovation measures are needed, information on local aid and financial support [3]. The 2016 regional energy and climate plan of Bruxelles Environnement, the environmental department, includes a measure to strengthen the CRIPI’s diagnostic and remediation services with regard to indoor pollution [1].
Primary energy savings	No information
CO_2 emission savings	No information
Costs	No information available
Increased renovation rate and depth	No information
Ease of implementation	• Transferability: theoretically possible, but might need education of staff (doctors, environmental chemists); the measure is planned to be extended to vulnerable groups in public buildings, such as schools, nurseries and recreational spaces • Administration: regional level (environment and energy administration in the Brussels-Capital region) • Compliance checks: one year after the initial analysis of the conditions and suggestion of measures, an evaluation of the evolution of the state of health is carried out by direct contact with the resident and the treating doctor via a questionnaire [3].

Matching EU policy framework	The collection of health and wellbeing data on the indoor environment can contribute to the integration of IEQ in building policies; the assessment of indoor pollutants based on a doctor's request could be a good practice to identify vulnerable consumer groups and users eligible for funding of renovation measures.
Addressing • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	Improve health and wellbeing: • The CRIPI's main objective is to improve the health and wellbeing of homeowners and tenants. By assessing the indoor environmental quality, identifying indoor pollutants and initiating the required action, IEQ is improved, leading to better health and wellbeing of the building residents. Between 2000 and mid-2011, the CRIPI carried out more 1,400 housing visits and 5,600 direct debits in apartments and houses, among which 57% of the samples were contaminated with polluting sources, such as benzene (37%), VOC (11%), formaldehydes (1.2%) or lead (5.5%) [3]. Secure fair transition: • A healthy indoor environment without harmful pollutants is essential to the wellbeing of all. This policy targets residents with adverse health effects or a concrete disease caused by their living situation. The identification of pollutants and subsequent improvement of the building helps a fair transition with regard to vulnerable (health affected) groups. The fact that the CRIPI unit is extended to vulnerable groups (especially children in schools, nurseries, recreational spaces) adds to that.
Lessons learned	• Success factors (strength and opportunities) – Evaluation of indoor pollutants and direct connection with health effects – Education and training of staff – Local guidance and information on local support programmes for renovation works – Monitoring of findings and establishment of a database • Challenges of implementation (weaknesses and threats) – Renovation measures not always implemented – Assessment has to be initiated by a doctor's request, meaning evaluation is not precautionary but only when health is already affected
Synergies	No
Bibliography	[1] Plan Régionale Air-Climate-energie. Bruxelles Environnement (2016). https://document.environnement.brussels/opac_css/elecfile/PLAN_AIR_CLIMAT_ENERGIE_FR_DEF.pdf [2] Bruxelles Environnement website. CRIPIhttps://environnement.brussels/thematiques/air-interieur/depolluer-son-interieur/cripi [3] CRIPI - an environmental diagnosis tool for indoor pollution, complement to medical diagnosis (2015). Bruxelles Environnement https://document.leefmilieu.brussels/opac_css/doc_num.php?explnum_id=6433

5.2 California (US) - Healthy Housing Rewards (Fannie Mae)

Policy/initiative	Fannie Mae Healthy Housing Rewards, California, US
Location	National level
Start year	2018
Status	Ongoing
Building types	Residential multi-family buildings
Type of policy	Financing incentive scheme for healthy building design and health services for residents
Short description	The Federal National Mortgage Association (FNMA), also known as Fannie Mae, is a company sponsored by the US government. With the Healthy Housing Rewards, Fannie Mae provides financial incentives (discounted loans) to lenders who incorporate health-promoting design and residents' services in their new or renovated affordable multi-family buildings. The properties must be Fitwell certified, a US building health certification system [3]. The rewards system follows two options: Healthy Housing Rewards Healthy Design: • Strategies to improve indoor air quality • Features encouraging physical activity • Includes common space, community gardens, playgrounds or exercise facilities • US$6,000 for Fitwell certification Healthy Housing Rewards Enhanced Resident Service: • If the property offers resident services to improve health and stability of users (health and wellness programmes, food access, youth education, work and financial capability support, housing stability support) • US$5,500 Certified Organization for Resident Engagement and Services (CORES) sponsor certification • US$750 Enhanced Resident Services (ERS) property certification costs paid by Fannie Mae [1] The rewards system is eligible for multifamily affordable housing properties with rent or income restrictions in place (at least 60% of tenants are low income groups with 60% of area median income or less) [2].
Primary energy savings	No information
CO_2 emission savings	No information
Costs	No information
Increased renovation rate and depth	No information
Ease of implementation	• Transferability: Theoretically transferable to other housing companies or financial institutions; could be transferred to low-income private homeowners who incorporate aspects of a healthy building design (not necessarily limited to rental properties); collaboration between lenders and certification system needs to be established (possibility to ensure compliance with WELL certification system) • Administration: By the private mortgage association Fannie Mae, nationwide

	• Compliance checks: Buildings have to be Fitwel certified (certification system committed to building health), expenses are covered by Fannie Mae
Matching EU policy framework	A similar financial incentive targeting healthy building design could be implemented within the frame of the Smart Finance for Smart Buildings initiative. As the initiative aims at mobilising private resources for an uptake of energy-efficient buildings, a cheaper loan could motivate lenders to invest in the health and wellbeing of building users. Another option is to incentivise healthy building design connected to certified buildings under the NextGeneration EU (Recovery facility) and other EU funding streams.
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	Improve health and wellbeing: • The Fannie Mae incentive programme directly improves the health and wellbeing of residents in affordable multifamily buildings. The Healthy Design Rewards scheme ensures a good indoor air quality and the establishment of community spaces that increase the wellbeing of users. The Healthy Housing Resident Services scheme goes beyond the building features and offers access to healthy food, wellness and recreational activities Secure fair transition: • The Healthy Housing Rewards programme targets affordable apartment buildings that address low income groups
Lessons learned	• Success factors, strength and opportunities – Financial incentive for healthy affordable housing targets vulnerable people – Loan break subject to Fitwell (healthy housing) certification prevents false allocation of benefit – Healthy Housing Enhance Resident Services goes beyond good indoor air quality but offers education support, recreational spaces and other wellbeing-promoting features • Challenges of implementation (weaknesses and threats) – Private sector initiative, no information on costs or energy savings
Synergies	Not applicable
Bibliography	[1] Fannie Mae (2020). *About Healthy Housing Rewards*. Fannie Mae Website. https://multifamily.fanniemae.com/financing-options/specialty-financing/healthy-housing-rewards [2] Fannie Mae (2019). Frequently Asked Questions (FAQs) Healthy Housing Rewards™ Healthy Design. https://multifamily.fanniemae.com/media/8486/display [3] Fitwel website, US healthy building certification scheme. https://www.fitwel.org

5.3 California (US) - Green Building Ordinance, San Mateo

Policy/initiative	Green Building Ordinance, San Mateo (US)
Location	Regional level (County of San Mateo, California, US)
Start year	2008
Status	Ongoing
Building types	New and renovated residential buildings and commercial buildings >3000 m²
Type of policy	Mandatory building certification system
Short description	Chapter 14 of Division VII of the San Mateo County Ordinance Code (California, US) [1] includes a green building programme to enhance public health and welfare by encouraging green building measures. Measures, among others, are to increase energy efficiency and lower energy usage as well as to promote a healthier indoor environment. The ordinance regulates that all new residential buildings (single-/two-family homes, low-rise multi-family houses) or alterations/renovations of > 50% have to be LEED certified or receive 50 GreenPoints or more on the appropriate GreenPoint Rated Checklist (GreenPoint Rated is the building certification system of "Built It Green", a non-profit organisation publishing green building guidelines in the US [5]). With a GreenPoint Rated at 75 points or higher or a LEED for Homes certification the processing of building permits can be expedited, and with 100 points or higher or LEED for Homes certification, a guaranteed building inspection within two working days is provided [1]. New commercial and industrial buildings of >3000m², including alterations, also have to prove that they will be LEED certified to receive a building permit. With a LEED Silver certification building inspections within two working days of request are guaranteed [1]. Other US counties and cities have implemented similar mandatory LEED certifications of new and altered buildings, e.g. the Bellingham city council in Washington state which requires all new municipal buildings and renovations >5000m² to earn LEED Silver certification given that the city council provides a majority of the funding. Similar regulations for new municipal buildings are in place in Austin (Texas), Boston (Massachusetts) and Chicago (Illinois) [2].
Primary energy savings	In 2012, 404,000m² of floor space was LEED certified [3]
CO_2 emission savings	No information
Costs	No information
Increased renovation rate and depth	No information
Ease of implementation	Transferability: building certification, including a strong health and wellbeing category assessment, could be implemented in most countries. Prerequisites would be trained and qualified staff and a green building council and regional/ local authority or private company to implement the certification process. The mandatory nature of private certification schemes is unlikely to be implemented in Europe due to the independence of public authorities. In California, the mandatory certification could be transferred to existing buildings undergoing renovations.

	Administration: The policy is administered on regional level by the San Mateo county council Compliance checks: Before issuing the final building permit completed certificates from Built It Green or LEED must be submitted to the building inspection section. Temporary occupancy can be granted if the certificates are not provided prior to a final building permit inspection, requiring a US$5000 deposit. Complementary measures: The San Mateo green building ordinance regionally complements the 2007 CALGreen Californian green building standard code for residential and non-residential buildings [4].
Matching EU policy framework	Mandatory inclusion and monitoring of health and wellbeing/thermal comfort aspects in energy performance certificates.
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	Improve health and wellbeing: • The LEED Homes certification includes several minimum required indicators to be fulfilled, such as ventilation, radon-resistant construction, air filtering and combustion venting. Given these have to the fulfilled to receive certification new residential buildings will have high health and wellbeing standards. The GreenPoint Rated system also includes indicators, like advanced mechanical ventilation for indoor air quality and installation of carbon monoxide alarms. Increased sustainable infrastructure in built environment: • LEED building certification covers a resource-efficient design and construction of buildings, contributing to the objective of a sustainable built environment. LEED Zero certifies carbon-neutral buildings.
Lessons learned	• Success factors, strength and opportunities – Indoor environmental quality category in the LEED certification scheme – GreenPoint Rated also includes indoor air quality/health category [5] – Outreach to and education of building community is essential to securing their cooperation in a green building programme – LEED training for county staff • Challenges of implementation (weaknesses and threats) – Focus on new buildings
Synergies	Not applicable.
Bibliography	[1] County of San Mateo, State of California, Ordinance 4444. An Ordinance amending Chapter 14 of Division VII of the San Mateo County Ordinance Code (Building Regulations), consisting of sections 1401-1408, modifying the green building program. http://www.co.sanmateo.ca.us/vgn/images/portal/cit_609/51/53/1338972748GreenBuildingOrdinance.pdf

[2] USGBC, WGBC & C40 (2015). *Green Building City Market Briefs.* https://www.c40.org/researches/c40-usgbc-and-wgbc-green-building-city-market-brief-compendium

[3] Sustainable San Mateo Council (2013), Indicators for a Sustainable San Mateo Council, Annual Report 2013 http://www.sustainablesanmateo.org/wp-content/uploads/2013/05/2013-Indicators-For-A-Sustainable-San-Mateo-County.pdf

[4] Building Standards Commission, CALGreen (Titel 24, part 11) https://www.dgs.ca.gov/BSC/Resources/Page-Content/Building-Standards-Commission-Resources-List-Folder/CALGreen

[5] GreenPoint Rated certification system https://www.builditgreen.org/greenpoint-rated

5.4 Ireland – Warmth and wellbeing scheme

Policy/initiative	Warmth and Wellbeing Scheme, Ireland
Location	Local level (designated location may change)
Start year	2016
Status	Ongoing
Building types	Residential buildings (owner-occupied or rented from a local authority/ approved housing association)
Type of policy	Grant
Short description	The Warmth and Wellbeing Scheme is a grant scheme launched in 2016 as a pilot under the government's Strategy to Combat Energy Poverty and the "Healthy Ireland Framework" by the Irish government. The scheme offers free deep energy upgrades to energy-poor households for people diagnosed with chronic respiratory conditions for three years in a designated location (currently Dublin). The initiative is led by the Department of Communications, Climate Action and Environment (DCCAE), in conjunction with the Department of Health and the Health Service Executive (HSE) and administered by the Sustainable Energy Authority of Ireland (SEAI) [1]. The free upgrades are available for children under the age of 12 and people aged 55 and over who live in households receiving a fuel allowance or the Irish one-parent family payment in respect of the child applying. The chronic respiratory disease must be officially diagnosed by the HSE, which also has to approve the application. If an application is successful a dedicated SEAI team assesses the home and recommends energy efficiency upgrades. Further, a survey identifies which energy efficiency measures are suitable for the building and users. The following measures are covered for homes built before 2006 with up to €20,000 per household: • Standard attic insulation and appropriate ventilation • Wall insulation: cavity, internal wall and/or external wall with appropriate ventilation • Boiler replacement as appropriate (oil or gas) • Draught proofing as appropriate • Other energy efficiency related upgrades where recommended. Contractors have to be listed under the SEAI Better Energy Homes Schemes and a post-works building energy rating (Irish energy performance certificate) is issued.
Primary energy savings	No information
CO_2 emission savings	No information
Costs	€20 million budget allocated [3] (€10 million available for 2017)
Increased renovation rate and depth	~400 homes were upgraded in 2016 and ~700 in 2017
Ease of implementation	• Transferability: the pilot scheme could be expanded nationwide in Ireland to benefit a higher number of residents depending on the budget allocated. Transferability to other European countries is possible but should take the share of chronic obstructive pulmonary disease (COPD) patients in the respective country into account. According to OECD health Ssatistics, Ireland has the highest COPD rate (2013) followed

	by Hungary and New Zealand [3]. Prerequisites are productive cooperation between health and energy departments and authorities and an effective application process. • Administration: administered nationally by SEAI • Compliance checks: energy efficiency measures are subject to the SEAI Better Energy Homes regulations including the list of qualified contractors. A post-works inspection issues a building energy rating and verifies that the measures installed are in accordance with SEAI's technical specification and relevant standards and regulations. • Complementary measures:The pilot scheme is launched under the Strategy to Combat Energy Poverty and adds to the other Better Energy Homes grants. No enabling measures exist.
Matching EU policy framework	
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	**Energy poverty:** The pilot scheme directly targets vulnerable, energy-poor households that receive social benefits. **Improve health and wellbeing:** The main objective of the scheme is to improve the health and wellbeing of residents with chronic respiratory diseases. As the renovation works and all connected services are delivered free of charge to people with adverse health effects, the scheme directly improves health and wellbeing of those residents.
Lessons learned	• Success factors, strength and opportunities – Approval through healthcare officials to assure the criteria are met – All services (application process, assessment of building) are free for the homeowner/user – Post-works building energy rating (EPC) • Challenges of implementation (weaknesses and threats) – Referral-based scheme, no direct application to SEAI possible – Limited residents eligible
Synergies	The free deep renovation scheme helps to phase out inefficient buildings (targeted and energy-poor households), thus addressing the strategic area of engaging transformation.
Bibliography	[1] SEAI (2018). *Get a Free energy upgrade for your home and health.* Booklet by the Sustainable Energy Authority Ireland. https://www.seai.ie/grants/home-energy-grants/free-upgrades-for-eligible-homes/warmth-and-wellbeing/2018-10-WarmthWellbeingA5Booklet.pdf

	[2] Straton, G. (2018). *Healthy Ireland and the Warmth and Wellbeing Pilot Scheme.* Energy Action European Energy Poverty Conference 2018. Presentation for the Health and Wellbeing Unit, Department of Health, Government of Ireland. https://energyaction.ie/ea/wp-content/uploads/2018/12/Greg-Straton-HSE.pdf [3] Department of Communications, Energy & Natural Resources (2016). *A Strategy to Combat Energy Poverty, 2016-2019*. https://www.dccae.gov.ie/en-ie/energy/publications/Documents/5/A%20Strategy%20to%20Combat%20Energy%20Poverty%20-%20Web%20Version.pdf

5.5 *Ireland - Home Performance Index (HPI)*

Policy/initiative	Home Performance Index (HPI)
Location	National level
Start year	2016 (second version HPI v2.0 from 2019)
Status	Ongoing
Building types	(New) residential buildings
Type of policy	Voluntary certification system
Short description	The Home Performance Index (HPI) is a voluntary certification system launched in 2016 in Ireland to complement existing schemes in the commercial sector, such as BREEAM and LEED. Developed by the Irish Green Building Council (IGBC), the HPI provides a quality label for sustainable residential development while promoting health and wellbeing aspects [1]. The certification scheme is built on five categories (Environment, Health & Wellbeing, Economic, Quality Assurance and Sustainable Location) that are evaluated by 30 indicators, some of which require post-completion performance tests. For certification, buildings have to comply with minimum standards exceeding building regulation and be checked by a qualified HPI assessor [2]. In 2019 the latest version was introduced with additional health and wellness performance criteria aligning it with WELL Building indicators to be approved under WELL Communities certification. The HPI v2.0 includes a zero carbon standard taking operational and embodied carbon into account [1]. Health and wellbeing indicators include mechanical ventilation, daylighting, sound insulation, risk of overheating, radiant asymmetry, low VOC specification and testing, radon testing, water quality and walkable neighbourhood [2]. To ensure a good performance in use, a post-completion evaluation after 12 months is carried out to check if buildings perform as expected. Although designed initially for new homes only, the intention is that the HPI should be developed further for all housing, using the key indicators to benchmark all buildings [3].
Primary energy savings	No information
CO_2 emission savings	No information
Costs	No information
Increased renovation rate and depth	• > 130 homes have been built and certified under the HPI system • Another 2,150 being registered for certification in the construction phase
Ease of implementation	• Transferability: the certification could – as planned – be used for existing buildings as well to certify major renovations, which might require additional compliance checks and training of HPI sssessors. The expansion to other building types would overlap with the existing schemes, e.g. the LEED system.

	Some other countries have similar schemes, e.g. the DGNB system in Germany, though health and wellbeing indicators could be transferred to stress the importance of this category. • Administration: administered nationally by the Irish Green Building Council • Compliance checks: compliance with the numerous indicators is evaluated by certified HPI assessors before certification and 12 months post-completion to ensure appropriate in-use performance. • Complementary measures: the certification scheme is aligned with the Irish national building regulation (Building Regulation TGD L 2019), EU CEN standards, European Commission's Level(s), the Zero Carbon Standard by the International Living Future Institute and is approved under the WELL Building Standard as a WELL Community Rating. The voluntary certification scheme complements the Irish EPC by going beyond the building regulation.
Matching EU policy framework	HPI indicators could be integrated into national EPCs to include the health and wellbeing category more thoroughly (as for example is already done in Portugal).
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	Improve health and wellbeing: • HPI-certified buildings can improve the health and wellbeing of residents as the scheme covers indoor air quality, ventilation, noise prevention, VOC and radon testing as well as water quality. As the certification system currently mostly covers new buildings an improvement doesn't necessarily happen but good health of the building users can be maintained. Increased sustainable infrastructure in built environment: • The HPI v2.0 launched in 2019 introduced a net zero carbon standard through combining exemplary credits in various criteria (energy in use, carbon in use, embodied impacts of homes and LCA, post-occupancy evaluation). Further, the health and wellbeing indicator "summer and winter comfort" ensures that homes are designed to avoid overheating in summer months and are resilient to temperature extremes due to climate change over their lifetime. Upgrade of urban context: • The additional category of sustainable location with the indicators of options for transportation (accessibility of public transport, availability of low emission transport options, availability of walking and bicycle paths) and access to amenities (parks and open spaces, education, medical care etc.) adds a dimension of the urban context of the building and sustainable mobility to the certification.
Lessons learned	• Success factors, strength and opportunities – Comprehensive categories and indicators (including mandatory minimum requirements) – Post-occupancy performance check • Challenges of implementation (weaknesses and threats) – Private initiative, not mandatory
Synergies	The broad range of categories and indicators also affects other strategic areas, such as district sustainable built environment and adaptation as well as clean and sustainable mobility (see above).
Bibliography	[1] Home Performance Index (HPI) website

	http://homeperformanceindex.ie [2] IGBC (2019). Home Performance Index (HPI) Technical Manual - Version 2.0. Horizon 2020 funded. http://homeperformanceindex.ie/wp-content/uploads/2020/01/HPI-Technical-Manual-v2.0.pdf [3] IGBC (2018). Creating an energy efficient mortgage for Europe – Building assessment briefing: Ireland https://www.worldgbc.org/sites/default/files/EeMAP_Building_Assessment_Briefing_IRELAND.pdf

5.6 Poland – Clean Air Programme

Policy/initiative	Clean Air Programme Poland
Location	National level
Start year	2018 (planned until 2029)
Status	Ongoing
Building types	Single-family residential buildings
Type of policy	Grant
Short description	The Polish Clean Air Programme aims at improving air quality and reducing GHG emissions from the residential building sector by replacing fossil fuel heat sources and supporting the financing of energy efficiency improvements of single-family residential buildings. The financing of the energy efficiency and renewable energy measures combines grants (funded by the National Fund for Environmental Protection and Water Management (NFOŚiGW) and the Provincial Fund for Environmental Protection and Water Management in Warsaw (WFOŚiGW)) with bank loans to municipalities and the Polish thermomodernisation tax relief. Support can be obtained by building owners and co-owners with an annual income not exceeding PLN 100,000 (€22,650) for the replacement of an ineffective heat source with solid fuel and for energy efficiency improvement measures, e.g. thermal insulation of the building envelope, replacement of windows, external doors, hot water installation, the use of mechanical ventilation with heat recovery and the application of renewable energy sources. Grants are given out for projects between 7,000 and 53,000 PLN. Energy audits are covered up to 100% while the costs for new heating installation are co-financed at 45-50% with a maximum of €5,700 for a replacement of a solid fuel heating system with a heat pump (up to €6,800 with PV). An increased level of funding is granted for building owners with a low income (up to €450 per month for a single household) with funding levels of up to 75% (max. €8,400). As of March 2019, 24,150 applications for works in existing building were submitted and close to 10,000 for new buildings. After initial criticism by the European Commission the design (administration, application process, involvement of private banking sector) was adapted with the second edition of the programme in May 2020 [6].
Primary energy savings	• 37,500 GWh/year saved (final energy consumption) [1] → 4.8 % of total 2030 target (based on 2030 target according to draft NECP saving 770,000 GWh (66.2 Mtoe)) The assessment of the progress made by Member States towards the national energy efficiency targets for 2020 (EU COM (2019) 224) states that final energy consumption has not fallen in Poland since 2005.
CO_2 emission savings	• 14 000 000 t CO_2 saved per year (whole programme) [1] • Poland emitted 413,781,000.40 tonnes of CO_2 in 2017 (OECD GHG emissions statistics)
Costs	PLN 103 billion (€23.4 billion) total budget from 2018 – 2029 [3]. 2018-2019: 80,000 applications for a total amount of over PLN 1.8 billion (€409 million) of grants and loans [3].

Increased renovation rate and depth	Objective to renovate three million buildings over the length of the programme (10 years) Context: Total single-family dwellings: 12.1 million (https://ec.europa.eu/energy/eu-buildings-database_en) meaning 25% of detached residential buildings are planned to be renovated (current "medium" renovation rate at 1.5%, 0% deep renovations according to JRC (2019))
Ease of implementation	• Transferability: the main objective of the programme is to improve the national air quality which is among the worst in Europe due to a high share of coal-fired power plants and old heating installations in residential buildings [4]. Transferability is possible to (neighbouring) countries with similar energy structure (high share of coal power plants leading to high levels of air pollution). • Administration: the programme is administered nationally by the National Fund for Environmental Protection and Water Management with the help of local authorities. • Compliance checks: compliance controlled by National Fund for Environmental Protection and Water Management and the Provincial Fund for Environmental Protection and Water Management in Warsaw during and after the works. • Complementary measures: since 2020, integration with the "My Electricity" programme, enabling applicants to obtain a grant of up to 5,000 PLN for installing a photovoltaic power generation system, without the need to submit two separate applications.
Matching EU policy framework	ESI funds Funding mobilised under Renovation Wave (dedicated to countries with high air pollution and high levels of energy poverty)
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	Energy poverty: • The scheme explicitly targets low income groups with old, polluting heating systems and grants higher amounts of funding to building owners with very low income. Improve health and wellbeing: • As the main objective of the scheme is to exchange old, coal-fired heating system to improve the local air quality, the programme tackles the adverse health effects of the high level of air pollution in Poland. Also, additional thermomodernisation works improve the health and wellbeing of residents.
Lessons learned	• Success factors, strength and opportunities – Support by municipal staff to fill out and verify applications (after initial criticism, changed in the new edition from May 2020) – Expanded distribution network to over 650 municipalities with second edition of the programme

	– Amount of grant and share of financial support determined by household income [1] – Simplified application process (now online) and shorter process time (30 days) from 2020 • Challenges of implementation (weaknesses and threats) – Administration via national and regional fund, not effective; criticism on poor distribution by the European Commission in the beginning due to design of the scheme [6] – One-third of the budget goes to new buildings, not replacing any old heating systems thus not addressing the objective [6] – No commercial banks involved in the beginning (changed from May 2020)
Synergies	
Bibliography	[1] Programme details. Official government website (2020) https://czystepowietrze.gov.pl/wp-content/uploads/2020/04/Program-Priorytetowy-Czyste-Powietrze.pdf [2] Status of implementation Clean Air Programme and outlook implementation by 2030, presentation from March 15, 2019. https://ec.europa.eu/energy/sites/ener/files/documents/mslupeczanska_-_stan_realizacji_pp_czyste_powietrze_i_perspektywy_jego_wdrozenia_do_roku_2030.pdf [3] Polish government website, "The Clean Air programme was launched a year ago" https://www.gov.pl/web/climate/the-clean-air-programme-was-launched-a-year-ago [4] Report from the Commission to the European Parliament and the Council (2018) 2018 assessment of the progress made by Member States towards the national energy efficiency targets for 2020 and towards the implementation of the Energy Efficiency Directive as required by Article 24(3) of the Energy Efficiency Directive 2012/27/EU https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52019DC0224&from=EN [5] World Bank (2019) The fight for clean air in Poland requires both knowledge and determination. https://blogs.worldbank.org/europeandcentralasia/fight-clean-air-poland-requires-both-knowledge-and-determination [6] EURACTIV (2019) Poland's multi-billion-euro clean air quest in peril. https://www.euractiv.com/section/air-pollution/news/polands-multi-billion-euro-clean-air-quest-in-peril

5.7 *Portugal – Energy Certification of Buildings and IAQ EPC*

Policy/initiative	Certificado de Desempenho Energético e da Qualidade do Ar Interior Energy Certification of Buildings and Indoor Air Quality, Portugal
Location	National level
Start year	2013
Status	Ongoing
Building types	Residential and non-residential buildings
Type of policy	Energy performance certificate
Short description	The Energy Certification of Buildings and Indoor Air Quality in Portugal presents a good practice example of the energy performance certificate (EPC) required by European legislation. The latest amendment of the Portuguese energy certification regulation of 2013 (Decree-Law no. 118/2013, of 20 August) transposed the 2010 EPBD recast into national law. Since 2006, indoor air quality components were included in the EPC. Indoor air quality parameters regulated by the certification scheme are carbon monoxide, carbon dioxide, formaldehyde, and fungal as well as relative humidity, volatile organic compounds, particulate matter and ozone. Different requirements apply to EPCs for existing and new buildings in the residential and non-residential (commercial and service) sector [2]. With the new 2013 decree, only 8 energy classes (A+ to F) are valid and there is an obligation to display the energy certificate in all non-residential buildings with areas greater than 250m² and to certify all public buildings with areas greater than 250m². In addition, any residential or service building that initiates a process or intention to sell or lease must have a valid EPC and indicate the energy class in the advertisement [3]. The Portuguese EPCs are valid for 10 years or 6-8 years for residential and commercial/service buildings respectively. A new calculation methodology was introduced with the 2016 roadmap preventing a clear comparison of the real energy consumption of buildings calculated according to the old methodology. Consumers do not have enough information or knowledge to understand the differentiation [3]. The energy efficiency certification scheme website provides a clear overview of national statistics, including the ratio of EPC scores in all Portuguese regions and the amount of measures implemented [3].
Primary energy savings	No information
CO_2 emission savings	No information
Costs	1.3 million EPCs issued by 2018 (90% in residential buildings) (iBRoad Factsheet) of ~ 6.9 million buildings (European Building Stock Observatory) → ~ 19% of buildings Cost range for an EPC: €135-€465
Increased renovation rate and depth	No information available
Ease of implementation	Transferability: under the EPBD, all Member States implement a form of EPC, though large discrepancies exist in the methodology, quality assurance and enforcement. The IAQ parameters could be included in

	the EPCs in other Member States with appropriate regulations, a comprehensive compliance process and regular testing. Different European projects (Horizon 2020) are currently developing options for improved EPCs, including the integration of IEQ features, such as comfort (see X-tendo project). Administration: administered nationally by ADENE, the Portuguese energy agency Compliance checks: the "Quality Verification Scheme" is structured into two phases. The first is the prevention phase which takes place before the EPC is issued and includes an on-site visit and automatic database control. The second phase is the correction phase, taking place after the EPC has been issued. Complementary measures: the Energy Efficiency Buildings Certification Scheme is complemented by other policy initiatives. These include the energy labelling of installations and products with the voluntary CLASSE+ certification and the online portal casA+. CLASSE+ indicates how energy efficient building products are (e.g. installations, windows, etc.). CasA+ functions as a one-stop-shop and centralises all relevant information about the building in one accessible location besides providing building owners with potential renovation measures [1].
Matching EU policy framework	The EPBD requires all EU Member States to implement national energy performance certificates in Article 11 and 12. The design and verification methodology differs a lot between Member States and prevents comparison and a harmonised quality assurance. The Renovation Wave could ensure a more stringent implementation of EPCs across EU countries and require more detailed features, such as indoor environmental quality (see Horizon 2020 projects X-tendo, QualDeEPC, U-Cert).
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	Improve health and wellbeing: • As all new, sold or let residential buildings have to issue an EPC and comply with the IAQ regulations, the building owners have the incentive to improve health and wellbeing aspects.
Lessons learned	• Success factors, strength and opportunities – High uptake, with more than 1.3 million EPCs issued and 19% of the building stock covered [6].

	– Centralised database that provides insight into national and regional building performance and generates awareness amongst building owners and tenants. – Link with other policy programmes like casA+ and CLASSE+ that enhances public awareness about energy efficiency. • Challenges of implementation (weaknesses and threats) – Lack of awareness amongst building owners [5] – Training sufficient qualified experts that can perform energy audits [5] – Privacy issues related to public EPC databases [9] – The calculation methodology has changed drastically in the past 10 years. As a result, buildings that were certified in 2010 will receive a significantly different score in terms of primary energy use and emissions. This might cause confusions about actual energy performance and might deteriorate trust in the rating [10].
Synergies	The digital EPC and linked to online platforms like casA+ rely on digital infrastructure and contribute to the **digitalisation** of the building sector.
Bibliography	[1] Adene website "Energy Efficiency of Buildings" https://www.adene.pt/edificios [2] Energy performance certificates website https://www.sce.pt/estatisticas [3] Vaquero (2019). *Buildings Energy Certification System in Portugal: Ten years later.* Available online at International Conference on Energy and Environment Research, ICEER 2019, 22–25 July, University of Aveiro, Portugal https://reader.elsevier.com/reader/sd/pii/S235248471930472X?token=46FCBA9CA9FEED9A192792BE6079E4F7F140B2B38AA262ECD4627A5BE92F178F386A209D1D0DA7FDB24218D3AC699437 [4] https://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-portugal.pdf [5] http://ccap.org/assets/CCAP-Booklet_Portugal.pdf [6] http://ibroad-project.eu/wp-content/uploads/2018/01/iBROAD_CountryFactsheet_PORTUGAL.pdf [7] https://www.adene.pt/Files/flipbook/ADENE-PAO-2019-2021/mobile/index.html

5.8 Denmark – National building regulations (BR18)

Policy/initiative	Building regulations for thermal indoor climate, Denmark
Location	National level
Start year	2018
Status	ongoing
Building types	Residential and non-residential buildings
Type of policy	Regulation (Building code)
Short description	The latest Danish building regulations (BR18) include specific requirements related to good indoor environmental quality (IEQ), covering chapters on noise, light and thermal indoor climate [1]. Chapter 17 requires "satisfactory noise conditions in terms of health and comfort". Noise from buildings' technical installations and from traffic must be considered as well sound transmission between rooms (Chapter 17, §368, 2). §368,3 states that documentation on noise conditions can be obtained by calculation or measuring in the finished building. Noise levels for residential units must be in accordance with call C in "DS 490 Sound classification of residential units" [1]. For non-residential buildings, noise specifications are determined in the "Guidelines in the building regulations on sound conditions". Chapter 18 requires that buildings "must have light conditions that ensure that no risk will occur to the health, safety and comfort of people" and daylight "must be utilised as a source of light to the extent it is possible". The planning and construction regarding daylight is subject to the "Guidelines of Transport, Building and Housing Agency on light and view of the surroundings" (Chapter 18, §379). §382-384 specify the use of electric light, including the obligation to test the lighting system before it is put into use. Chapter 19 outlines the general provisions for the indoor thermal climate and inspection, operation and maintenance of heating and cooling installations. §386 specifies that "In rooms where persons stay for a longer period of time, it must be ensured that a satisfactory thermal indoor climate can be maintained during the intended use and activity and relevant calculation documentation must be obtained for buildings" [1]. Installations for heating and cooling systems must be carried out so that they have sufficient capacity to ensure specified temperature conditions all year round. The thermal comfort is determined from the connection between the thermal indoor climate and the human activity and clothing (Specification and verification following DS 474 Standard for specification of thermal indoor climate and DS / EN ISO 7730). The installation of heating and cooling systems must comply with DS 469 Heating and cooling systems in buildings, ventilation systems with DS 447. §390 determines the energy consumption in accordance with DS 452 Thermal insulation of technical installations. Chapter 22 specifies requirements for ventilation for satisfactory air quality.
Primary energy savings	No information
CO_2 emission savings	No information
Costs	No information

Increased renovation rate and depth	No information
Ease of implementation	• Transferability: more EU countries could implement IEQ details into their building codes. • Administration: administered nationally by the Ministry of Transport, Building and Housing as part of their national building regulations (BR18).
Matching EU policy framework	The Renovation Wave, with a focus on improved IEQ, could communicate the Danish example of specified IEQ determinants in building regulations as a good practice example. The EPBD could require details on how to improve indoor air quality. An indoor comfort feature in EPCs could involve those aspects that are already required by the Danish building regulations to be implemented in other Member States.
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	Improve health and wellbeing: • The strong focus on good indoor environmental quality in new buildings in Denmark tackles the objective of improved health and wellbeing directly. The mandatory consideration of daylight, noise and indoor thermal climate is a prerequisite for a healthy indoor climate in both residential and public buildings.
Lessons learned	• Success factors, strength and opportunities – Mandatory requirements and performance checks – Specific guidelines on national conditions with exact requirements on noise, daylight, ventilation and thermal comfort • Challenges of implementation (weaknesses and threats) – Lack of compliance and mandatory checks – Lack of detailed specifications and actions
Synergies	Not applicable
Bibliography	[1] Danish Ministry of Transport, Building and Housing (2018). Executive Order No. 1615 of 13 Dec. 2017, January 2018. https://bygningsreglementet.dk/~/media/Br/BR-English/BR18_Executive_order_on_building_regulations_2018.pdf [2] Danish Ministry of Transport, Building and Housing (2018). Buidling regulations, Thermal indoor climate and installations for heating and cooling systems (§ 385 - § 392)

	https://bygningsreglementet.dk/Tekniske-bestemmelser/19/Vejledninger/Termisk-indeklima [3] Energy Requirements BR18 – A quick guide for the construction industry on the Danish Building Regulations 2018 https://www.byggeriogenergi.dk/media/2202/danishbuildingregulations_2018_energy-requirements.pdf

5.9 Sweden - Grant for radon remediation for homeowners

Policy/initiative	Radon grant, Sweden
Location	National level
Start year	2018
Status	Ongoing
Building types	Detached residential buildings
Type of policy	Grant
Short description	In 2018 the Swedish National Board of Housing, Building and Planning adopted a regulation on subsidies for measures to reduce radon contamination in detached houses (Regulation 2018: 7). The policy determines the volume of subsidies paid for radon elimination in small one- and two-family houses. Due to the high radon levels among Swedish residential buildings, the government decided to fund 50% of reasonable costs (up to €2,500) of radon decontamination. In 2020, the overall budget amounts to SEK 34 million (€3.3 million). The removal of radon in living spaces improves the indoor air and the residents' health as radon contamination above 200 Bq (becquerels) / m^3 can cause health issues (e.g. increased risk of lung cancer). Tests are initiated by the building owner or the landlord and can be supported by the respective municipality (public health office). According to the Swedish Environmental Code, the municipality can also demand radon checks if findings suggest inconveniences for human health. Sweden's national accreditation body, Swedac, lists accredited companies that measure radon in the air. An expert has to measure the indoor radon content and recommend measures to alleviate radon, such as ventilation measures, sealing against the ground, installing radon suction or constructing a radon well. The ordinance 2018:158 presents how to carry out measurements: to determine an annual average, tests are to be conducted for at least two months during the heating season, in at least two rooms used every day. The testing has to be done with calibrated instruments, and applicants are recommended to follow the Swedish Radiation Safety Authority's measurement method.
Primary energy savings	Does not necessarily save energy as not the objective
CO_2 emission savings	Does not necessarily save CO_2 emissions as not the objective
Costs	Grant budget of €3.3 million in 2020
Increased renovation rate and depth	No information
Ease of implementation	• Transferability: possible to countries with high radon levels possible • Administration: grant administered on national level, supported by municipalities (supervisory responsibility to check compliance with regulation (building code states that radon levels have to be below 200 Bq/ m^3). • Compliance checks: testing by accredited expert (listed with Swedac, the national accreditation body) No legal requirement for regular checks but it is recommended to do radon tests once a house is sold or altered, when the ventilation or heating system is changed, or after 10 years.

	• Complementary measures: the Swedish building regulations BFS 2011:6 with amendments up to BFS 2018:4 regulate in Article 6:23 that the "annual activity concentration of radon in the indoor air must not exceed 200 Bq/m³".
Matching EU policy framework	
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	Improve health and wellbeing: • The main objective is the financial support of radon alleviation thus improving the residents' health.
Lessons learned	• Success factors, strength and opportunities – Direct funding of radon decontamination measures – Comprehensive information on radon contamination on government websites • Challenges of implementation (weaknesses and threats)
Synergies	Not applicable
Bibliography	[1] Website of the National Board of Housing, Building and Planning. Apply for radon susidies. https://www.boverket.se/sv/bidrag--garantier/radonbidrag/ [2] Website of the National Board of Housing, Building and Planning. Check the radon content. https://www.boverket.se/sv/byggande/halsa-och-inomhusmiljo/radon/ [3] Swedac. List of accredidated companies. https://search.swedac.se/sv/ackrediteringar?s=aktivitetsm%C3%A4tning [4] Swedish Radiation Safety Authority. Supervisory guidance radon – homes and premises to which the public has access https://www.stralsakerhetsmyndigheten.se/publikationer/handbocker/tillsynsvagledning-radon--bostader-och-lokaler-dit-allmanheten-har-tilltrade/

5.10 Sweden - Obligatory ventilation control for housing

Policy/initiative	Obligatory ventilation control, Sweden
Location	National level
Start year	1991
Status	Ongoing
Building types	Residential, public and office buildings (except for houses with S or F ventilation)
Type of policy	Regulation
Short description	The Swedish Planning and Building Act (2010:900), Chapter 8, section 25 regulates the regular checking of ventilation systems for most buildings depending on the type of ventilation. The Planning and Building Act as well as the Planning and Building Ordinance (2011:338) require the owner of a building to ensure "the function of the ventilation system in the building is checked before the system is used for the first time (first inspection) and thereafter regularly on recurring occasions (recurring inspection)" in order to maintain "a satisfactory indoor climate" (Chapter 5.1). Municipal building committees are required according to Chapter 12, Section 1 to check compliance with the obligatory ventilation control. The controller must also provide suggestions on how to reduce energy consumption for ventilation without this giving rise to a poorer indoor environment. One- and two-family homes with fan (F) or natural (S) ventilation are excluded from the requirement according to Chapter 5, section 1. The inspections have to be carried out at 3- or 6-year intervals depending on the type of buildings: • Three years: Preschools, schools, care facilities regardless of ventilation system and apartment and office buildings with FT (mechanical supply and exhaust air ventilation) and FTX (fan-controlled supply and exhaust air system with heat recovery) ventilation • Six years: Apartment and office buildings with F, FX (mechanical exhaust air ventilation) and S ventilation.
Primary energy savings	No information
CO_2 emission savings	No information
Costs	No information
Increased renovation rate and depth	No information
Ease of implementation	• Transferability: mandatory ventilation control regulations can be transferred to other countries which have to comply with the EPBD regulations • Administration: administered locally by the installed municipal building committees • Compliance checks: qualified experts to carry out ventilation controls must be accredited and are listed on a central website (Boverket); the municipalities may apply financial penalties if inspection intervals are not followed • Complementary measures: complements the ventilation regulation set out in Sweden's building code based on EU EPBD requirements

Matching EU policy framework	An EPBD revision could increase ventilation requirements and improve enforcement of existing legislation (Inspection of building installations, Article 15 EPBD) to improve air quality.
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	Improve health and wellbeing: • A well-functioning ventilation system is essential for healthy indoor air quality.
Lessons learned	• Success factors, strengths and opportunities – Implementation and compliance checks by municipal committees at regular intervals according to building types and ventilation systems • Challenges of implementation (weaknesses and threats) – No connected information measures, building owners have to be aware of the funding possibilities
Synergies	Not applicable
Bibliography	[1] Boverket´s building regulations – mandatory provisions and general recommendations, BBR (BFS 2011:6 with amendments up to BFS 2018:4) https://www.boverket.se/en/start/publications/publications/2019/boverkets-building-regulations--mandatory-provisions-and-general-recommendations-bbr [2] Boverket - National Board of Housing, Building and Planning. Obligatory Ventilation Control (OVK) (website) https://www.boverket.se/en/start/building-in-sweden/swedish-market/laws-and-regulations/national-regulations/obligatory-ventilation-control [3] A Handbook on the Planning and Building Act https://www.boverket.se/sv/PBL-kunskapsbanken/regler-om-byggande/ovk/ovk-besiktning

5.11 Umeå, Sweden – Grant for noise protection

Policy/initiative	Umeå noise grant, Sweden
Location	Local level
Start year	2015
Status	Ongoing
Building types	Residential buildings
Type of policy	Grant
Short description	Residents in the municipality of Umeå, Sweden who own a residential property can apply for a grant to finance the replacement of windows for noise protection based on the ordinance (2015: 216) on traffic noise in residential buildings [1]. Homes located on streets are targeted as they are heavily affected by traffic noise. Grants are awarded if all of the following conditions are met: • The property is exposed to road traffic noise above 70 dBA more than five times per night (10 pm – 6 am) • The maximum indoor noise level exceeds 50 dBA before replacement measures. Or if all of the following conditions are met: • The sound level (daily average) at the facade exceeds or is equal to 61 dBA free field value (calculated by the municipality according to the Nordic calculation model) • The equivalent indoor noise level exceeds 35 dBA before the works. Grant applications are prioritised under heavier conditions (e.g. exceeding the maximum level of 70 dBA more than 10 times per night). The grants are allowed for buildings built before 1997, as for buildings built after this, the national buildings code's noise regulations apply (National Board of Housing, Building and Planning) [2]. The volume of the grants amounts to €183 (1,875 SEK) per m² of window size which is only granted for windows facing the street side. The programme is administered by the 'Street and parks' department of the Umea municipality (who are also responsible for carrying out sound measurements) but the building owner is responsible for the works (selection of contractor, implementing the schedule). It has to be assured that the ventilation works properly after the window measures have been implemented [2]. After the measure, the equivalent indoor level may not exceed 30 dBA and 44 dBA maximum at night. Prior to the payment, control measurements must be carried out and approved by the municipality. The property owner must also have submitted a copy of the technical specification of the measures [2].
Primary energy savings	No information
CO_2 emission savings	No information
Costs	
Increased renovation rate and depth	No information

Ease of implementation	• Transferability: possible to other countries depending on noise levels and capabilities on local level to measure as well as available financial resources. • Administration: administered locally, by the 'streets and parks' department of Umea. • Compliance checks: noise measurements after implementation of the window replacement works. • Complementary measures: the grant scheme complements the national building code that regulates noise protection for buildings built after 1997.
Matching EU policy framework	Possible context (not building renovation): the EU Directive 2002/49/EC on the assessment and management of environmental noise requires Member States to submit noise mapping reports for municipalities of >100,000 inhabitants. From 31 December 2018, it has been obligatory to use the new Cnossos-EU (Common Noise Assessment Methods in EU) assessment methods in connection with strategic noise mapping (http://www.swedishepa.se/Guidance/Guidance/Noise/Strategic-noise-mapping-). The Renovation Wave establishing a stronger focus on IEQ, including noise protection, could channel financial resources to similar noise protection grants.
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	Improve health and wellbeing: • The grant scheme aims at alleviating disturbances from traffic noise (road, train, air traffic) for residential buildings thus directly improving the wellbeing of the respective residents.
Lessons learned	
Synergies	
Bibliography	[1] Umeå municipality website, Noise protection grant https://www.umea.se/umeakommun/byggaboochmiljo/bullerochluftkvalitet/buller/bullerskyddsbidrag.4.232bb3eb132b9e0c2ca800068080.html [2] Guidelines for noise protection allowances for window measures at road traffic noise, Umeå municipality https://www.umea.se/download/18.5ec3fe241709e2c4377629c/1583832579887/Riktlinjer%20bullerskyddsbidrag%2020200310.pdf

5.12 US/International – WELL Building Standard

Policy/initiative	WELL Building Standard
Location	National level
Start year	2014
Status	Ongoing
Building types	Developed for institutional buildings, now also residential buildings
Type of policy	(Healthy) building certification scheme
Short description	The International WELL Building Institute (IWBI) launched the WELL Building Standard™ in 2014 as a performance-based building certification scheme focusing on health and wellbeing of users. Initially targeted at commercial and institutional buildings, the certification standard today can be applied across many sectors. The certification criteria are air, water, nourishment, light, fitness, comfort and mind that are measured and monitored. The certification system is available in three project types in silver, gold and platinum certification: 1. New and existing buildings 2. New and existing interiors 3. Core and shell The performance verification of the WELL Building Standard is subject to an on-site assessment by an authorised 'WELL Performance Testing Agent'. The standard is certified by the Green Business Certification Inc. (GBCI), complementing the LEED building certification scheme that is implemented by the same company, developed in 1990 in the UK. In Italy, the WELL Building Standard is promoted through a collaboration between APTA VITAE Trust, an Italian non-profit organisation, and IWBI since 2017.
Primary energy savings	No information
CO_2 emission savings	No general information
Costs	No information
Increased renovation rate and depth	In 2020 4,395 projects were applying the WELL standard across 62 countries.
Ease of implementation	• Transferability: the WELL Building Standard has already spread over multiple European and non-EU countries. IWBI has established partnerships with, e.g. the Blue Building Institute (Netherlands), and Polish Green Building Council (PLGBC). A further expansion to more countries is possible, depending on competition with already used certification schemes. • Administration: the global certification scheme is administered by the Green Business Certification Inc. (GBCI). In Italy, it is administered nationally by cooperation between IWBI and the Italian APTA VITAE Trust. • Compliance checks: the certification is issued based on an assessment of WELL accredited professionals. In 2018 nearly 300 industry professionals were accredited in Europe [4]. • Complementary measures: the WELL standard complements the LEED certification scheme that is administered by the same

	company, Green Business Certification Inc. (GBCI). GBCI administers several certification schemes, among others TRUE, a zero waste certification programme for businesses, and EDGE, a green building certification system focused on making buildings more resource-efficient.
Matching EU policy framework	Features of the (private) WELL Building Standard could be replicated to improve the next generation of EU EPCs. The dedicated wellbeing criteria, such as comfort and mind, and the connected indicators could be taken up in a further development and function as best practice for EPC design in the Member States.
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	Improve health and wellbeing: • WELL certified buildings improve the health and wellbeing of buildings users as they require certain IEQ standards to be fulfilled, e.g. mould control, limiting pollutants and contaminant concentrations as well as monitoring air quality and increasing ventilation (for all indicators see https://a.storyblok.com/f/52232/x/8c8027863e/well-v1-pdf-with-2019-q1-addenda_0.pdf).
Lessons learned	• Success factors, strength and opportunities – Extensive list of indicators covering aspects of IEQ – Accreditation process of WELL professionals, including a two-year maintenance period – WELL certification guidebook as good practice guidance document – Complementary nature of LEED and WELL (qualification of assessment overlaps) – Collaboration on assessment methods between WELL and BREEAM certification • Challenges of implementation (weaknesses and threats) – Strong focus on commercial and office buildings
Synergies	
Bibliography	[1] WELL Building Standard website https://www.wellcertified.com [2] Apta Vitae website https://www.aptavitae.com/en [3] BusinessWire website (2018) WELL Building Standard gaining momentum in Europe. https://www.businesswire.com/news/home/20180518005447/en/Building-Standard-Gaining-Momentum-Europe

5.13 UK – BREAAM Certification scheme

Policy/initiative	BREEAM Certification System (UK)
Location	National level
Start year	1990
Status	Ongoing
Building types	Initially office buildings, now all residential and non-residential buildings
Type of policy	Building certification system
Short description	BREEAM is a method of assessing, rating and certifying the sustainability of new and existing buildings. Launched in 1990 in the UK, the Building Research Establishment Environmental Assessment Methodology was initially developed for large office buildings but is now spread over almost all building types and used in the UK, Norway, Sweden, Spain and the Netherlands. The tool aims to quantify and reduce the environmental burdens of buildings by rewarding those designs that take positive steps to minimise their environmental and human health impacts. It is typically undertaken to demonstrate compliance with environmental regulations but can also be a planning requirement. There are different categories in which a domestic or non-domestic project (in-use, new build or renovation) is assessed. An assessment must be undertaken by a qualified BREEAM assessor. A dedicated standard for renovation projects, the BREEAM Refurbishment and Fit Out (RFO), aims at certifying the performance of building upgrades with a version for (international) non-residential buildings and residential buildings in the UK. It is currently used across Europe with certified assessments in the UK, France, Italy and Poland. Partner scheme operators exist in the US, the Netherlands, Spain, Germany, Norway, Sweden, Austria and Switzerland. The health and wellbeing category of the globally used non-residential certification scheme includes the indicators visual comfort, indoor air quality, safe containment in laboraties, thermal comfort, acoustic performance, safety and security and hazard. The categories for UK residential buildings include daylighting, sound insulation, volatile organic compounds, inclusive design, ventilation and safety, with ventilation and safety being minimum standards. Projects can reach the rating of Pass (≥30% of the required score), Good (≥45%), Very Good (≥55%), Excellent (≥70%) and Outstanding (≥85%).
Primary energy savings	No information
CO_2 emission savings	No information
Costs	No information
Increased renovation rate and depth	No information
Ease of implementation	• Transferability: high – the certification scheme is already implemented and used in several European countries (see above). The distribution over building types is also spreading (from non-residential to residential). • Administration: administered by a national certification body (BRE Global) or national partner operators across Europe

	• Compliance checks: compliance with the numerous indicators and requirements is checked by a qualified, accredited BRE assessor during and after completion of the project. The project management includes a "handover and aftercare" section which may cover a site inspection within three months of occupation, post-occupancy interviews/ surveys and the provision of a helpline for longer-term support. Extra credit to achieve a higher level of certification is given where thermographic surveying and airtightness testing are carried out at both pre- and post-refurbishment stages.
Matching EU policy framework	Features of the (private) BREEAM certification could be replicated to improve the next generation of EU EPCs. The dedicated health criteria and the underlying indicators could be taken up in a further development and function as best practice for EPC design in the Member States.
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	Improve health and wellbeing: • The health and wellbeing category of the BREEAM certification includes minimum required indicators to be fulfilled and gives a better rating to building projects with higher IEQ indicators, e.g. ventilation, accessibility and daylighting. Increased sustainable infrastructure in the built environment: • BREEAM building certification aims at a resource-efficient design and construction of buildings, contributing to the objective of a sustainable built environment. Indicators for refurbishment projects include flood protection and low-emission materials.
Lessons learned	• Success factors, strength and opportunities • Challenges of implementation (weaknesses and threats) – Private initiative
Synergies	Not applicable
Bibliography	[1] BREEAM website. https://www.breeam.com [2] BRE Briefing Paper, Sustainable refurbishment of domestic buildings using BREEAM. https://tools.breeam.com/filelibrary/Brochures/63945---Sustainable-refurbishment-of-domestic-buildings-using-BREEAM.pdf

6 GOOD PRACTICE EXAMPLES: DISTRICT APPROACHES

The following pages provide examples of good practice policies in the strategic area of *district approaches.*

6.1 The Netherlands – Natural Gas-Free Districts Programme

Policy/initiative	Programma Aardgasvrije Wijken/Natural Gas-Free Districts Programme
Location	National
Start year	2018 (learning phase from 2018 to 2021)
Status	Ongoing (learning phase)/planned (large-scale implementation)
Building types	All buildings within covered districts
Type of policy	Capacity building/grants
Short description	The Dutch National Climate Agreement includes the aim to make the Dutch buildings sector natural gas-free. Whereas implementation is mainly the responsibility of the local level, a national programme was launched to support Dutch districts/municipalities to become natural gas-free through deep renovations and integration of renewable heating at district level. The objective of the programme is to get 1.5 million buildings natural gas-free by 2030. The first step is a "learning phase" running from 2018 to 2021 (with a budget of €400 million), based on two pillars: • A "knowledge and learning centre" (accessible for all Dutch municipalities) will provide technical support and facitiltate information sharing/best practices • Frontrunner municipalities or districts can get financial support for demonstration/implementation as "testbeds for natural gas-free districts". In a first round, 27 testbeds have already received funding, while 77 municipalities have applied for funding in the second round. Next steps (after 2021) still have to be developed.
Primary energy savings	• Impact varies between the different testbeds that will receive funding, and the approach each municipality eventually develops to become natural gas-free • No information available yet on the results of the testbeds • The programme has recently developed a monitoring system to assess the impact. First results are expected for 2022.
CO_2 emission savings	• Impact varies between the different testbeds that will receive funding, and the approach each municipality eventually develops to become natural gas-free • No information available yet on the results of the testbeds • The programme has recently developed a monitoring system to assess the impact. First results are expected for 2022.
Costs	• No information available on the total cost of achieving the objectives of the programme (1.5 million buildings natural gas-free by 2030) • The budget for the learning phase of the programme (2018-2021) is €400 million
Increased renovation rate and depth	• Impact varies between the different testbeds that will receive funding, and the approach each municipality eventually develops to become natural gas-free • No information available yet on the results of the testbeds • The programme has recently developed a monitoring system to assess the impact. First results are expected for 2022.

Ease of implementation	• Other countries could develop similar initiatives 1) with a clear objective, 2) where implementation is mainly the responsibility of the local level, and 3) where the national level provides support through capacity building and financial support. However, this would require a strong engagement of and interaction between all actors involved (national authorities, local authorities, private sector, …). The Dutch National Climate Agreement has played a central role in this regard. • The Dutch programme is not a standalone programme, but is linked to several other initiatives and policies which are all included in the Dutch National Climate Agreement. Other initiatives include the Transition Vision Heat (commitment of all municipalities to develop a strategy to become natural gas-free), the Regional Energy Strategy (similar as the Transition Vision Heat, but at a regional level), etc.
Matching EU policy framework	The link with the EU policy framework depends on the approach the different municipalities will take to become natural gas-free. Nevertheless, it can be expected that overall, the programme and its objectives will contribute to increased energy efficiency (e.g. better insulation, recovery of waste heat for district heating) and increased use of renewable energy (e.g. switch to biofuels, electrification in combination with renewable electricity production). This in turn could be linked to the: • Energy Efficiency Directive • Renewable Energy Directive • Energy Performance of Buildings Directive • Effort Sharing Regulation • Renovation Wave initiative
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	Depends on the approach the different municipalities will take to become natural gas-free.
Lessons learned	• Strengths: – Clear mid- and long-term objectives (fully natural gas-free by 2050, 1.5 million buildings by 2030 as an intermediary goal), which are in line with climate neutrality by 2050

	– Integrated in a broader policy agenda, and complemented by other policies (via the National Climate Agreement) – Broad stakeholder support through the governance process leading up to the National Climate Agreement (e.g. roundtables on the buildings sector) – Encourages an integrated approach (efficiency + renewable energy) with sufficient flexibilities to adapt to local circumstances. The objective is to become natural gas-free: each municipality can decide for itself which is the best way to achieve this goal, based on the local potential of the different options (e.g. nearby presence of waste heat, etc.) – Clear division of roles (national vs. local level), with support from the national level (both capacity building and financial) • Weaknesses: – The bulk of the efforts to achieve the objective will have to be done after the learning phase (as of 2022). No clarity yet on how this will be achieved (no next steps/budget provided so far) • Opportunities: – Will put the energy transition on the agenda of all local authorities – Could therefore encourage these authorities to integrate the energy transition in their overall policies (in particular urban planning) – Opportunities to share lessons learned and best practices via the knowledge and learning centre • Threats: – A lot of responsibility is left to the local authorities (municipalities). There is a risk that these do not have the required resources (personnel, know-how, financial resources) to achieve the ambitious objectives (in particular smaller municipalities). Unclear whether the support provided by the national level will be sufficient in this regard – No clear governance process to ensure that all municipalities follow up on their commitments – Unclear what the following steps will be after the learning phase. Next steps will have to be based on lessons learned, but the timing for developing next steps (before 2022) and achieving the objective (1.5 million buildings natural gas-free by 2030) is very challenging – Delivery of the objectives is therefore uncertain
Synergies	Not applicable
Bibliography	https://aardgasvrijewijken.nl/default.aspx

6.2 *The Netherlands – Renovation Accelerator*

Policy/initiative	Renovatieversneller/Renovation Accelerator
Location	National
Start year	2020
Status	Ongoing
Building types	Residential buildings owned/managed by larger housing corporations
Type of policy	Various: • Capacity building/process facilitation • Grants
Short description	The Renovation Accelerator is a national programme to incentivise large scale energy renovations by large housing corporations. The programme seeks to bundle/aggregate the demand for renovation of similar housing types, and then facilitate a match with the supply chain. This should improve the cost-effectiveness of renovations, through standardisation, economies of scale, the optimisation of supply chains, etc. The programme works on the following dimensions: • It takes the role of a facilitator to match housing corporations with each other and with actors from the supply chain, e.g. by organising events where these actors can meet each other. • It provides technical and process assistance to support relevant projects (e.g. sharing of best practices and knowhow on best available technologies, organising joint procurement procedures, etc.). • It provides grants/subsidies to renovation projects. Only projects covering at least 150 housing units built before 1995 and involving at least two corporations (each with at least 50 housing units) are eligible. Subsidies vary between €2000 and €7000 per housing unit, depending on the type and the achieved energy performance. The budget for the period 2020-2023 is €100 million.
Primary energy savings	• Only renovation projects that achieve a maximum heating need of 70 kWh/m^2 are eligible for a subsidy (increased subsidy if the performance is below 50 kWh/m^2. • With a budget of €100 million over four years (2020-2023), the subsidy scheme could renovate between 14,000 and 50,000 housing units over this period. • Final energy savings depend on the energy consumption before and after the renovation, the average surface, and the type of dwellings that receive grants.
CO_2 emission savings	No information available
Costs	The budget for the subsidy scheme is €100 million for the period 2020-2023 (€20 million for each of the first two years, €30 million for each of the last two years). No information available (yet) on the private investments leveraged through the programme.
Increased renovation rate and depth	• The programme only started in 2020, no evaluation results available yet. • If all subsidies are granted, over the four-year period:

	– Between 33,000 and 50,000 housing units would be renovated to a level of maximum 70 kWh/m^2 heating demand – Between 14,000 and 25,000 housing units would be renovated to a level of maximum 50 kWh/m^2 heating demand. • This would be an increase compared to the "few thousand" housing units currently being renovated each year, but the exact increase in innovation rate would have to be assessed *ex post*.
Ease of implementation	• Similar programmes could be implemented in other countries or for other building types, depending on the structure of the market and the building stock: • It can be particularly useful for countries (like the Netherlands) where a large share of the building stock is owned by large housing corporations, and/or where the building stock is relatively homogenous within certain districts (e.g. neighbourhoods with all identical buildings, which allow for a one-size-fits-all approach and economies-of-scale cost reductions) • It would be less suitable for countries where the market is dominated by household ownership (households being the owner of their own dwelling) and/or where the building stock is more heterogenous (requiring tailor-made renovation solutions, therefore reducing the potential for economies of scale). • The programme is mainly administered by the Ministry of Economic Affairs. • The policy is embedded in a broader national policy framework with the overall goal to make the Dutch building stock climate neutral and natural gas-free by 2050 (with intermediate objectives for 2022 and 2030). It is an instrumental part of the "Start Engine", which aims to get 100,000 building natural gas-free by 2022. Other, complementary policies and programmes are the Natural Gas-free Districts Programme, adjustments to the rules on housing rentals, etc.
Matching EU policy framework	• The policy directly contributes to the Renovation Wave initiative and the objectives of the Energy Efficiency Directive.
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition	• Though it depends on the eventual renovation projects that will be subsidised, in general terms the renovation of housing units can contribute to reducing energy poverty, improving health and wellbeing, etc.

• Upgrade of urban context (including access to sustainable mobility)	
Lessons learned	• Strengths: – Combination of financial incentive and process/technical assistance – Ambitious requirements for renovations (70 to 50 kWh/m^2) • Weaknesses: – No integration/requirements with regard to low-emission heat generation (e.g. renewables) • Opportunities: – Could trigger a large number of additional renovations (due to the 150 housing units threshold) – Could trigger important cost savings and speed up renovations (through economies of scale and optimisation between demand and supply) – Even proven successful, a continuation of the programme (and if necessary, increase of the budget) could trigger a renovation wave within the housing corporation-owned building stock, which constitutes a significant part of the Dutch building stock • Threats: – Potential risk of windfall profits, if the cost savings and subsidies are not passed through in market prices (either within the supply chain, from the supply chain to the housing corporations, or from the housing corporations to the lessees)
Synergies	Financing renovations: the programme provides a financial incentive to overcome the landlord-tenant dilemma (= market failure). Engaging transformation and phasing out energy-inefficient buildings: the programme targets older, inefficient buildings (built before 1995) where spontaneous renovations might be less likely due to the landlord-tenant dilemma. By setting ambitious energy-saving criteria, it incentivises deep renovations.
Bibliography	www.renovatieversneller.be https://www.rvo.nl/subsidie-en-financieringswijzer/renovatieversneller

6.3 *Belgium – Neighbourhood Grant*

Policy/initiative	Burenpremie (Neighbourhood Grant)
Location	Regional
Start year	Effective start in October 2017
Status	Ongoing
Building types	Residential (single-family buildings, multi-family buildings, etc.)
Type of policy	Grant
Short description	The objective of this grant is to stimulate collective renovation, though no quantified objective has been defined. It is financed by the regional network operator and is part of the regional policies. **How does it work?** The grant is allocated to the leader of a collective project to renovate several houses or apartments in the same street or neighbourhood. The project leader will make energy renovations more efficient, faster to implement, of higher quality and less expensive thanks to a collective approach. They will lead on tasks such as housing energy diagnostics, timings of works, carrying out surveys, finding contractors, site monitoring and requesting other subsidies. A list of certified project leaders is available. Training is organised by the network operator. Anyone is eligible to be a project leader provided they have sufficient architectural and technical knowledge, and understanding of the phased approach to construction projects and financing questions. The appointed project leader for collective renovations must be commercially independent from professional players in the building sector to assure objective guidance and advice. For the citizen, it increases the certainty about the smooth running of the renovation works and guarantees lower investment costs. Additional information: • The project must include at least 10 houses or apartments. • The grant differs for single-family buildings (€400 per house) and for multi-family buildings (€100 per housing unit and capped at €5000 for an entire building). • The collective project action plan must invest in at least one of the seven measures of the total renovation subsidies: roof or attic insulation, wall insulation, basement/ground insulation, new glazing, solar boilers, heat pumps, pump boilers or ventilation systems. • A list of 500 active project leader is available.
Primary energy savings	• Impact will depend on the number of collective projects applying, and the number of housing units and the specific refurbishment renovation ambition of each project • No quantified information available
CO_2 emission savings	• Impact will depend on the number of collective projects applying, and the number of housing units and the specific refurbishment renovation ambition of each project • No quantified information available
Costs	Cost will depend on the number of collective projects applying, and the number of housing units and the specific refurbishment renovation ambition of each project.
Increased renovation rate and depth	• Impact will depend on the number of collective projects applying, and the number of housing units and the specific refurbishment renovation ambition of each project. • No quantified information available

Ease of implementation	• Other countries could offer similar subsidies at regional or national level in any region or climate zone. The renovation plan designs custom solutions for each collective project and can be implemented for specific building types. The concept could be extended to non-residential buildings. • However, this would always require interaction between all actors involved (national authorities, local authorities, regional network operators, regional energy agency and certified project leaders). To ease coordination and decision-making, financing could come from national or local authorities rather than network operators. The key point is to make it easier to set up collective projects by bringing project leaders and citizens into contact with each other. • The neighbourhood grant is part of a group of subsidies proposed by the regional authority. The grant covers specific measures specified within the regional renovation plan. This ensure consistency in objectives pursued by all regional subsidies. Being included in a group of renovation subsidies helps to increase visibility and initiation of such district initiatives.
Matching EU policy framework	The link with the EU policy framework depends on the approach of each collective project. Nevertheless, as it supports specific measures under the regional renovation plan, it can be expected that overall, the grant and its objectives will contribute to increased energy efficiency (e.g. better insulation) and increased use of renewable energy (e.g. increasing solar, pump boilers or heat pumps implementation). It will also encourage citizens to renovate their homes, which might not have materialised without a collective approach. This in turn could be linked to the: • Energy Efficiency Directive • Renewable Energy Directive • Energy Performance of Buildings Directive • Renovation Wave initiative
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	• Depends on the approach and ambition of each collective project, but the realisation of a collective residential project can improve health and wellbeing within the community.
Lessons learned	• Strengths:

	– Lower investment costs for individual citizens, thanks to the collective approach – More efficient renovation and potential deep renovation as the renovation action plan will be designed by a skilled project leader. • Weaknesses: – The amount of the grant is low compared to the total renovation costs – This grant could help to initiate new project, but should be followed by tools and initiatives to facilitate the project once started. • Opportunities: – Encourages citizens to renovate their homes by simplifying renovation processes, improving the overall renovation rate of the residential building stock – Offers new renovation solutions thanks to the collective scale: shared sustainable mobility solutions, large-scale heating systems, etc. • Threats: – It is the responsibility of regional authorities to ensure the success of the grant programme by providing support to collective project constitution (list of certified project leaders, training, advertising, coordination between actors…).
Synergies	Depends on the approach of each collective project.
Bibliography	https://www.energiesparen.be/burenpremie https://www.vlaanderen.be/burenpremie-voor-collectieve-renovatieprojecten https://www.fluvius.be/nl/thema/benoveren/benovatiecoach

6.4 European Union – MODER project

Policy/initiative	MODER Project (Mobilization of innovative design tools for refurbishing of buildings at district level)
Location	EU
Start year	2015-2018 (36 months)
Status	Finished
Building types	All building types
Type of policy	Initiative to develop decision-making tools to support renovation actors – offers tools, processes and policies that could be replicated at EU and local level
Short description	MODER was a European project funded by the Horizon 2020 programme, the main objectives of which were to promote energy-efficient renovation at the district level and help to achieve smart, sustainable, and inclusive economic growth in European and global markets. The tools (processes and business models) developed can evaluate the benefits to be achieved to support decision-making in designing renovation projects at district level. Concepts were tested through four real refurbishment cases and provide detailed data. Case studies include real databases of energy audited buildings, a mix of privately and municipally owned buildings, ongoing energy refurbishment projects, and districts where the value of the property has increased annually, leading to socio-economic issues. **Objectives:** • To develop tools for use at district and neighbourhood level to compare alternative renewable energy systems. • To improve understanding of the behaviour of complex energy systems for non-technical stakeholders through easy-to-understand visualisations of alternative energy scenarios. • To improve holistic energy-system design at district level considering renewable energy systems (through optimal selection and sizing of energy conversion units as well as the energy distribution system). • To develop processes and practices that enable building owners to activate refurbishment with the help of energy management companies and engineering companies. MODER also developed business models for engineering companies, consultants and energy managers to profitably offer these services for owners. **Target audience:** Engineering companies, energy managers, consultants, local authorities, municipalities, building owners, investors, local businesses **Partners:** SWECO as lead partner. LEAG and REM PRO reported the process for the national case studies.
Primary energy savings	Not applicable – impact depends on how tools are used beyond the MODER project
CO_2 emission savings	Not applicable – impact depends on how tools are used beyond the MODER project
Costs	The project received €3.28M from the EU Horizon 2020 research and innovation programme

Increased renovation rate and depth	Not applicable – impact depends on how tools are used beyond the MODER project
Ease of implementation	MODER models have been tested and validated with case studies across different European countries (Germany, Finland, Slovenia, Latvia…). Results have also been compared for different archetype buildings (predefined parameters for 21 archetypes). Models also include climate parameters. The targeted public is diverse – MODER tools can be used at different scales and by different profiles of renovation actors.
Matching EU policy framework	The project was financed by the EU Horizon 2020 programme, which aims to ensure Europe produces world-class science, removes barriers to innovation and makes it easier for the public and private sectors to work together in delivering innovation. The funding areas covered are energy efficiency and the rational use of energy, new and renewable resources, energy in transport and integrated initiatives. Being conducted and supported by this European programme ensured MODER's credibility and confidence in the results and tools developed, and alignment with the goals of Horizon 2020.
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	District level renovation projects supported by the MODER tools can help address: • Increased sustainable infrastructure in the built environment (including enhanced resilience of building) • Increase smart readiness of buildings
Lessons learned	• Strengths: – District-scale refurbishment is in line with sustainable, low-carbon and infill strategies of growing cities – District approaches support a rapid transition towards energy efficiency and renewable energy – MODER tools can help to communicate (and visualise) information about potential solutions for district-scale projects requiring deep and realistic analyses of potentials. • Weaknesses: – Collective projects can lead to possible disagreement between owners – Lack of skilled actors to initiate large-scale projects. Skills required include: ○ understanding platform-based approaches and methods to empower people

	○ organising participative processes, inquiries and workshops gathering potential groups of housing companies ○ helping end-users to define requests based on their own life and living situations – Institutional and legal obstacles related to town planning and building permission practices. • Opportunities: – Huge backlog of renovation (especially for residential buildings) that district scale refurbishment can drive. – MODER tools can help to identify new optimal refurbishment solutions (e.g. optimal design and operation of energy systems) – Identifying specific district profiles where the need for district-scale refurbishment is highest (e.g. growing urban areas, districts where the value of flats is high, suburban districts). – Proactive municipalities are key partners, being neutral and providing objective information about benefits and opportunities. They can be local facilitators, supporting collaboration with owners, owner-occupants, contractors and others. In addition, the municipality should support the platform-based approach, encourage participation of all, and provide open data. Municipalities could also provide a small incentive for forerunner housing companies, together with extensive information about benefits of refurbishment. Finally, the rental housing companies owned by the municipality should show strong leadership, demonstrate, and invite others to participate. – Opportunities for green funding • Threats: – Need to raise market interest and potential customers. Contractors, project managers and engineering companies must see the essential role they can play to ensure the success of district-scale refurbishment.
Synergies	Not applicable
Bibliography	https://projectsites.vtt.fi/sites/moder/www.vtt.fi/sites/moder/Pages/Brochures.html https://ec.europa.eu/easme/en/section/horizon-2020-energy-efficiency/h2020-programme#:~:text=Horizon%202020%20is%20the%20EU's,leadership%20and%20tackling%20societal%20challenges.

7 Good practice examples: engaging transformation

The following pages provide examples of good practice policies in the strategic area of *engaging transformation and phasing out inefficient buildings*.

7.1 England and Wales (UK) – Minimum Energy Efficiency Standard (MEES) regulations

Policy/initiative	Minimum Energy Efficiency Standard (MEES)
Location	Regional (England and Wales)
Start year	2018
Building types	Residential buildings in the rental sector
Status	Ongoing
Type of policy	Regulation
Short description	The MEES prescribes that all privately rented property must have an EPC level E to rent out the property on the rental market [2]. The MEES is made possible by the Energy Efficiency (Private Rented Property) (England and Wales) Regulations, which were amended in 2019 [1]. The regulation is applicable to buildings with specific types of tenancy agreements and that are legally obliged to have an EPC [2]. The UK government provides suggestions of measures that building owners can take to meet the requirement. Building owners are never required to invest more that £3,500 on energy efficiency improvements unless more external funding has been secured [2]. Various exemptions exist for building owners depending on the type and value of buildings and the cost-effectiveness of the measures.
Primary energy savings	No information was found about primary energy savings.
CO_2 emission savings	Expected emission savings are 4.3 $MtCO_2$-eq [5]
Increased renovation rate and depth	All private rental properties that have to comply with the regulation need to meet EPC rating E as of 1 April 2020 [2].
Ease of implementation	The degree of transferability of the policy depends on whether Member States have functioning EPC infrastructure and information about privately rented property. If this is in place, transferability can be high. The government of England and Wales has written the legislation, but it will be local governments that are responsible for the implementation and compliance checks amongst landlords.
Matching EU policy framework	EU Renovation Wave
Costs	Landlords are never required to invest more than £3,500 [2]. Total costs to the private sector are estimated at £986 million, equalling on average £34.5 million annually [5].
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built	Upgrade the urban context Improve health and wellbeing

environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	
Lessons learned	• Success factors, strength and opportunities – The fines are high enough to stimulate landlords to comply with the regulations [4]. – The regulation is perceived to be affecting behaviour of investors and created awareness amongst portfolio managers [4]. – The policy helps to address market failures like the split-incentive dilemma [5]. – Additional benefits related to health and comfort can be achieved [5]. – Many smaller portfolio managers have taken action to improve the quality of their buildings [4]. • Challenges of implementation (weaknesses and threats) – Compliance with MEES is considered too easy and the targets not sufficiently ambitious [4], which makes it unlikely that the MEES regulation will result in significant decarbonisation. – Enforcing compliance remains challenging due to lack of capacity of local authorities, lacking registration and licensing of landlords, and insufficient empowerment of tenants [3]. – Little evidence was found that deep-retrofits were achieved [4]. – Compared to the Scottish MMR for privately rented properties the English and Wales case has no significant financial support schemes in place, which might discourage building owners to invest in (deep) renovations [6].
Synergies	**Digital technology** and data analysis are mentioned as opportunities to improve compliance with the policy [4]. Furthermore, the policy might have positive side effects related to **health and wellbeing.**
Bibliography	[1] https://www.legislation.gov.uk/uksi/2019/595/contents/made [2]https://www.gov.uk/guidance/domestic-private-rented-property-minimum-energy-efficiency-standard-landlord-guidance#when-you-need-to-take-action-to-improve-your-property-to-epc-e [3]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/825485/enforcing-enhancement-energy-efficiency-regulations-English-private-rented-sector.pdf [4]https://assets.henley.ac.uk/defaultUploads/MEES-RREF-Report.pdf?mtime=20200310154440 [5]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/760313/IA_-_Energy_Efficiency__Private_Rented_Property___England.pdf [6]https://www.gov.scot/publications/energy-efficiency-private-rented-property-scotland-regulations-2019-guidance/pages/3

7.2 Brussels (Belgium) – Mandatory minimum requirements linked to BRP

Policy/initiative	Mandatory minimum requirements linked to a building renovation passport
Location	Regional level (Brussels)
Start year	Adoption 2021 / enforcement 2030
Building types	Residential buildings in the rental sector
Status	Planned
Type of policy	Regulation
Short description	The regional government of Brussels plans to implement mandatory renovation measures for residential and non-residential buildings to ensure a minimum energy performance of the building stock in 2050 [1]. The plan includes the formulation of five renovation measures to improve the energy performance, of which building owners must implement one on a five-year interval basis starting in 2030. The type of measures and the final performance requirements are based on the building typology and ownership [1].
Primary energy savings	Not specified.
CO_2 emission savings	Not specified.
Increased renovation rate and depth	No information on the expected depth of each renovation step is provided [1]. The goal is, however, to create 'energy neutral buildings' (NZEBs) in 2050.
Ease of implementation	The concepts of a building renovation passport and mandatory minimum requirements are applied in other countries already, which suggest that this policy could be transferred relatively easily to other countries. The regional government in Brussels is responsible for the implementation of the policy [1]. Other measures the policy interweaves with are [1]: • Establishing a single point of information for building owners and professionals • Establishing a renovation roadmap for residential buildings • Establishing a building passport
Matching EU policy framework	Renovation Wave **EPBD article 20** – Informing inhabitants about energy savings measures they can take to improve the energy performance of buildings
Costs	No costs have been specified yet.
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including	The renovation of all buildings in Brussels will lead to an **upgrade of the urban context.**

- enhanced resilience of building) - Increase smart readiness of buildings - Secure fair transition - Upgrade of urban context (including access to sustainable mobility)	
Lessons learned	- Success factors, strength, and opportunities – The plan links a mandatory minimum requirement with a long-term target while providing concrete stepwise options to building owners to meet this target. - Challenges of implementation (weaknesses and threats) – The plan does not include specific financial enabling measures.
Synergies	The building renovation passport could also include information about circularity of renovation measures, linking it to the **built environment sustainability and adaptation to climate change** strategic area.
Bibliography	[1]https://ec.europa.eu/energy/sites/ener/files/documents/bruxelles_capitale_2020_ltrs.pdf

7.3 Baden-Württemberg (Germany) – Support for serial renovation

Policy/initiative	Förderprogramm Serielle Sanierung von Wohngebäuden - Support for serial renovation in Baden-Württemberg
Location	Regional level
Start year	2019
Building types	Residential buildings
Status	Ongoing
Type of policy	Grant
Short description	The grants from the Baden-Württemberg government aim to stimulate the renovation rate through industrial pre-fabrication of building parts like façades, windows, doors and roofs for residential buildings constructed before 2002 [1]. The grant is provided per square metre of usable floor area and varies for different individual interventions, e.g. roofs or walls, or complete renovations [1]. The grant may not exceed 40% of the costs. Eligible complete renovations must amount to a minimum of €200,000 [1]. The grant programme is active until the end of 2023 [4]
Primary energy savings	No information available
CO_2 emission savings	No information available
Increased renovation rate and depth	No estimates or other information available
Ease of implementation	The Ministry of Environment, Climate and Energy of Baden-Württemberg is providing the funding and has made the Karlsruher Institute of Technology responsible for the implementation of the programme [1]. The measure is connected to the KfW efficiency house standard. If renovations comply with the KfW standard 55 or 70, the grant sum increases [1]. The support is enabled through the implementation of an administrative regulation in BW [2].
Matching EU policy framework	Serial renovation could be a key policy within the context of the **Renovation Wave** initiative from the European Commission. The grant provided by the government of Baden-Württemberg relates to Article 20 EED – Financing of Energy Efficiency.
Costs	€3M public funding is made available for the project [3]
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building)	The upgrading of the existing building stock is a form of **upgrading** of the urban context. Because housing associations are one of the most suitable starting points for industrial prefabrication and serial renovation, residents of social houses have a larger chance to see their living environment being upgraded. If the serial renovation is applied to social housing, this would contribute to **securing a fair transition**. Renovation may also improve smart readiness through links to building automation [1].

• Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	
Lessons learned	• Success factors, strength and opportunities – The grant from the government in Baden-Würtemmberg has contributed to initial market development of serial renovations in Germany [6]. In 2019, the first volume deal for serial renovation in Germany was signed, which could kick-start the market [5]. • Challenges of implementation (weaknesses and threats) – Costs of implementation have to be reduced after the initial investment stage.
Synergies	Industrial production of facades and walls requires **digital technology** like BIM and 3D printing, thus relating to the digitisation of the supply chain in the construction sector [5].
Bibliography	[1]https://um.baden-wuerttemberg.de/de/energie/informieren-beraten-foerdern/foerdermoeglichkeiten/foerderprogramm-serielle-sanierung-von-wohngebaeuden [2]https://um.baden-wuerttemberg.de/fileadmin/redaktion/m-um/intern/Dateien/Dokumente/5_Energie/Beratung_und_Information/190207_VwV_Serielle_Sanierung_GABLBW.pdf [3]https://www.baden-wuerttemberg.de/de/service/presse/pressemitteilung/pid/drei-millionen-euro-fuer-serielle-sanierung-von-wohngebaeuden [4] https://www.ptka.kit.edu/serielles-sanieren.html [5]https://www.energiesprong.de/newsroom/meldungen/durchbruch-fuer-serielle-sanierung-von-wohngebaeuden [6]https://www.energiesprong.de/newsroom/meldungen/umweltministerium-baden-wuerttemberg-foerdert-serielle-sanierung-von-wohngebaeuden

7.4 Lithuania – Renovation [modernisation] of multi-apartment buildings

Policy/initiative	Daugiabučių namų atnaujinimo (modernizavimo) programa –Multi-apartment building renovation (modernisation) programme
Location	Lithuania
Start year	2005
Building types	Multi-family buildings
Status	Ongoing
Type of policy	Grant and technical advice
Short description	The multi-apartment building renovation (modernisation) programme was initiated in 2005 to renovate multi-family buildings. The objective of the programme was to renovate 4000 (out of 38,000) multi-apartment buildings and save 1,000 GWh of energy annually between 2005 and 2020 [8] To be eligible for support the building needs to be constructed before 1993 and contain at least three apartments but may also include non-residential premises [1]. This accounts for roughly 90% of the apartment building stock in Lithuania [4]. Renovated buildings must obtain a minimum EPC rating of C and reduce primary energy consumption by at least 40% [5]. Building owners can participate in the programme on their own initiative or when the municipality has identified their building as appropriate for participation. In the latter case an administrator is appointed to administer the renovation of the building and building owners do not assume any organisational responsibilities, credit obligations or implementation risks [1]. Third-party financiers (UAB VIPA and Šiaulių bankas) provide long-term renovation loans with a duration of up to 20 years and fixed interest rate of 3% [2]. The Lithuanian government pays 100% of the project preparation, supervision and administration costs. Additionally, the Lithuanian government funds 30% of the costs for proposed measures and an additional 10% for specified heating installations [5]. If the annual interest rates of the soft loans provided by the third-party financiers exceed 3%, the government pays the difference [1]. For disadvantaged communities the government also pays credit insurance premiums and monthly credit and interest payments [1]. This boils down to complete coverage of the costs [7].
Primary energy savings	582.8 GWh/year [3] (2005-2018) for the whole programme. Other sources mention 828 GWh/year [8].
CO_2 emission savings	137.48 kton CO_2/year [3] (2005-2018) for the whole programme.
Increased renovation rate and depth	No data on energy performance after renovation was found, nor on the total floor area covered. However, in 2018 the calculated energy reduction was on average 70% (kWh/m^2) per project, for 498 apartment buildings. 55% of buildings got upgraded to EPC C and 44% to EPC B [6].
Ease of implementation	The administration of the policy is the responsibility of the Lithuanian Housing Energy Saving Agency, which receives funding from the state budget [5]. Their responsibilities include checking if the municipal programmes are in alignment with the national programme. Many formalities are described in relation to the decision-making procedures of condominium associations, and forms that must be

	completed and handed in at the Housing Energy Saving Agency before the start of the renovation project [1]. The projects have to be supervised and designed by qualitied engineers [7]. However, further compliance checks, e.g. for performance after renovation, are not mentioned. Relevant policies are the Law for Support for Renovation of Multi-apartment Buildings, the Lithuanian Construction Technical Regulations, the Methodology for calculating the thermal energy consumption of multi-apartment buildings, the Law on Condominium Associations, and the Lithuanian Housing Strategy [5].
Matching EU policy framework	This programme contributes to achieving the targets of the **Renovation Wave** initiative, for which it could be integrated as a good practice example. 2A – important for the LTRS - **EPBD**
Costs	Total investment from 2005-2013 was €368.5M [8] Costs in 2017 were on average €193/m^2 [8] Total investments from 2005-2019 are estimated at €600M of both private and public funds [9]. The European Investment Bank, which has provided funding for the programme, suggests a leverage factor of four for each public euro invested [9].
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	The programme helps to **upgrade the urban context** in Lithuanian cities. Furthermore, the additional support from the Lithuanian government for disadvantaged residents supports a **fair transition** while reducing **energy poverty**.
Lessons learned	• Success factors, strengths, and opportunities – After 2013 standardised documentation and contracts, the possibility for interim payments, open credit lines from third-party financiers and the possibility for qualified administrators was introduced [7]. This increased the popularity of the programme amongst building owners. – After 2013 municipalities mostly appointed the administrators of the renovation projects. • Challenges of implementation (weaknesses and threats) – Before 2013 there was a lack of standardisation, rigid payment options, no state funding and limited

	possibilities to appoint an administrator beside the chairman of the condominium association, resulting in low popularity of the programme amongst building owners [7]. – Success depends on the administrator appointed by the municipality or the building owner [7].
Synergies	The programme is also related to **financing renovation** because the funding for the programme was essential for its success [8]
Bibliography	[1]http://www.betalt.lt/veiklos-sritys/programos/daugiabuciu-namu-atnaujinimo-modernizavimo-programa/102?c-19/t-46 [2]https://sb.lt/lt/verslui/finansavimas/pastatu-atnaujinimo-modernizavimo-finansavimas/daugiabuciu-namu-atnaujinimo-modernizavimo-programa/pagrindines-finansavimo-salygos/projektai-suderinti-nuo-2017-11-01 [3]http://www.betalt.lt/doclib/anp3k3em7idp2x4ggajvrje43u1fuz1e [4]https://www.e-tar.lt/portal/lt/legalAct/TAR.AE67B6739526/plnWugajpq [5]https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/b585f210580311e78869ae36ddd5784f [6]http://www.betalt.lt/veiklos-sritys/programos/daugiabuciu-namu-atnaujinimo-modernizavimo-programa/102/?c-52/t-124 (see state support agreements have been concluded). [7]https://www.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1516631962.pdf [8]https://www.epatee-toolbox.eu/wp-content/uploads/2018/10/epatee_case_study_lithuania_renovation_programme_with_eu_funding_ok.pdf [9] https://www.eib.org/en/press/all/2019-001-new-financing-for-energy-efficiency-loans-in-lithuania-with-siauliu-bankas

7.5 Flanders (Belgium) – Digital building logbook

Policy/initiative	Woningpas (digital building passport).
Location	National level
Start year	2019
Building types	Single-family residential buildings [1]
Status	Ongoing
Type of policy	Informative policy instrument for building owners
Short description	The Woningpas is a free digital building renovation passport that offers building owners an overview of building-related information on one platform. This contains information on insulation, energy performance, installations, the soil, surroundings, the EPC, and renovation steps suitable to achieve an EPC A rating in line with the Flemish LTRS[2][3]. The Flemish government wants to facilitate building sale and renovation for citizens, and though clear communication and coordination the required paperwork is made more accessible. The Flemish government wants to achieve three concrete goals with the Woningpas: 1) Reduce the complexity of administrative processes 2) Provide insight into the energy performance of buildings 3) Create awareness around the 2050 targets for energy performance of the built environment. As such, the Woningpas supports the realisation of the Renovatiepact 2050 (Renovation Pact) which has the goal of a climate-neutral built environment in 2050 [4].
Primary energy savings	Because the Woningpas is an informative and enabling measure, the direct impact on primary energy savings is difficult to quantify.
CO_2 emission savings	Because the Woningpas is an informative and enabling measure, the direct impact on CO_2 emission savings is difficult to quantify. The Woningpas is mentioned as an important instrument to achieve the targets of the LTRS [3] which aims to reduce CO_2 emissions by 75% for residential buildings [5].
Increased renovation rate and depth	No information was found with regard to the increased renovation rate and depth directly related to the Woningpas.
Ease of implementation	The Woningpas has been launched through collaboration between four Flemish (regional) government departments and public agencies. The Flemish Energy Agency, the Public Waste Agency Flanders (OVAM), the Environment Department and the Housing Agency Flanders each contribute building-related information to the digital Woningpas platform [4]. Initially the Woningpas only included construction/renovation permits and the EPC. The objective is to support evolution of the tool to integrate other data sources so it can support, inform and incentivise building owners to renovate energy efficiently, healthy, comfortably and safely [4]. The Woningpas integrates various building-related data sources from different parties including the Flemish government, the building owner and the building sector supply chain. It will therefore contain different levels of information with varying credibility. Compliance checks take

	place on the level of input data, e.g. quality assurance of an EPC or compliance check of the building permit. Building owners can upload proof of energy performance renovation measures on the Woningpas, which in turn can recalculate the energy performance of the building [6]. The degree of transferability is theoretically high. In practice it depends on the availability of related buildings data and the collaborative capacity of various government institutions involved. Enabling policies for the Woningpas are EPCs, building permits and land register information that form the input data for the Woningpas. The measure weaves into other building renovation-related policies in Flanders like the Renovation Pact and the regional LTRS [5].
Matching EU policy framework	EPBD Article 11 – EPCs. The Commission could consider complementing article 11 and include (part of) the integral elements of the Woningpas as requirements for the EPC. Initiative: Renovation Wave. The clear information provision and coordination integrated in the Woningpas could help increase the renovation rate in the EU and thereby achieve the targets of the Renovation Wave. EED Article 17 – information and training. The Woningpas is a policy instrument that can support Member States to provide information to citizens about the practicalities and benefits of making energy efficiency improvements.
Costs	For building owners the Woningpas will be free [2][4]. The total budget for the development of the Woningpas from 2018-2022 (versions: Light, Medium, Full, 2.0 and Continued) is estimated at €3.2M [6]
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	The Woningpas supports the achievement of objectives related to smart readiness, upgrading the urban context and increasing sustainable infrastructure in the built environment. The Woningpas will allow building owners to digitally update their building renovation passport, which in turn can recalculate the EPC of a building [2]. In that way it addresses the needs of building owners through ICT, thereby contributing to **smart readiness of buildings**. The Woningpas also integrates data about the surroundings, e.g. related to cultural heritage value and sensitivity for flooding [2]. This type of information might support the **improvement of the resilience** of buildings. The Woningpas also stores the Mobiscore (Mobility score) of the building [2]. This score indicates how a district/building scores in terms of accessibility of important facilities by foot or bike [7]. When building owner awareness about the Mobiscore increases this might lead to **upgrading of urban contexts.**
Lessons learned	• Success factors, strength and opportunities – A strength of the Woningpas is that it is integral, multi-functional and modular. – The digital passport integrates data sources from various government departments that previously had

	to be contacted one by one, in addition to functioning as a storage folder for information uploaded by the building owner. – Due to the modular nature of the Woningpas, additional functionalities can be added step by step. This allows for an iterative process in which new functionalities can be tested, evaluated and included to the Woningpas when proven effective. – Consequentially, the Woningpas is multifunctional and can function as a comprehensive information platform for building owners, but also for other stakeholders in the building supply chain, e.g. architects, construction professionals and potential new buyers. • Challenges of implementation (weaknesses and threats) – The availability of data has to be secured and approved. Parliamentary questions in Flanders indicate that the release of the Woningpas was delayed due to regulatory checks and procedures related to the release of building-related data by the government [8]. – The credibility of the information presented in the Woningpas is essential for its success [6]. The validation of the data presented is therefore important. – The development of the Woningpas had to be in alignment with the privacy law of Belgium, especially in relation to information that can only be provided to others with the explicit consent of the building owner [6]. – One important idea of the Woningpas is that it can save administrative process time and provide updated information on the Flemish building stock. This could be achieved if building owners update the information on their building, e.g. after a renovation. However, if this is made obligatory building owners might perceive it as another obligation. Therefore, the requirement to update the Woningpas has been postponed and could be phased progressively in the future [6].
Synergies	**Digital technology** – the Woningpas functions as a centralised digital file accessible to the building owner.
Bibliography	[1] BEreel! (2019). 'Flemish houses now have a building passport'. Link [2] Vlaanderen. (n.d.). 'Over woningpas'. Flemish Government. Link [3] LTRS. (2020). 'Langetermijn Strategie Voor de Renovatie van Vlaamse Gebouwen'. Flemish Government. Link [4] Energiesparen (2018). 'Woningpas - Persdossier'. Flemish Government. Link. [5] Energiesparen (n.d.). 'Vlaamse langetermijnrenovatiestrategie voor gebouwen 2050'. Flemish Government. Link. [6] Energiesparen. (2016). 'Draft designnota Woningpas'. Flemish Government. Link [7] Mobiscore. (n.d.). 'Woning zoeken? Mobiscore checken!'. Flemish Government. Link [8] Flemish Parliament. (2018). 'Schriftelijke vraag 201 – Stefaan Sintobin'. Link

7.6 Germany – Individual renovation roadmap for residential buildings (iSFP)

Policy/initiative	Individueller Sanierungsfahrplan für Wohngebäude (Individual Renovation Plan for Buildings)
Location	National
Start year	2017 [1]
Building types	Residential (single-family buildings, multi-family buildings, etc.)
Status	Ongoing
Type of policy	Grant / building renovation passport
Short description	The Individueller Sanierungsfahrplan (iSFP) is a tool that provides residential building owners, condominium associations and tenants with a tailored building renovation passport with an approach to renovate their property. The Federal Ministry of Economic Affairs and Energy (BMWi) pays 80% of the costs for an energy audit by a certified expert, up to €1,300 for single and two-family buildings and €1,700 for multi-family buildings [2]. In practice building owners simply hire an energy auditor, who in turn applies for the financial support and provides the building owners with a reduced rate. This simplifies the procedures for the building owner. The certified expert provides the building owner with an overview of the energy performance of the building, the potential energy savings, recommendations for renovation steps and their cost-benefit ratio [2]. This provides building owners with trustworthy information about their energy consumption and the trade-offs between different renovation measures. The expert also indicates what financial support programmes are available. The iSFP provides the energy auditors with a predetermined reporting format and tool which makes the auditing process more efficient [1]. This format includes seven steps and instructions with regard to the software used, conditions applicable and information provided to the homeowner [3]. Following the audit, the building owner receives a tailor-made renovation schedule for their property in line with their wishes and budget. This can be a one-time deep renovation or stepwise renovation schedule [2]. This supports building owners to reduce their energy consumption.
Primary energy savings	Quantified primary energy savings estimates were not found for the iSFP separately but for the broader "energy advice for residential buildings programme". 2018: 59,863 MWh [7]
CO_2 emission savings	Quantified CO_2 emissions savings estimates were not found for the iSFP separately but for the broader "energy advice for residential buildings programme". 2018: 18,400 T CO_2 [7]
Increased renovation rate and depth	No specific numbers were found describing the overall increase and depth of the renovation rate.
Ease of implementation	The iSFP is part of the broader "Bundesförderung für Energieberatung für Wohngebäude" (Energy Advice for Residential Buildings) as a tool for energy auditors and is administered on a national level by the BMWi [4]. The tool is also linked to the KfW efficiency standard, because the auditor has to explain to the building owner how a one-

	time renovation can help achieve the KfW standard [8]. To simplify the process for building owners, the energy consultants have been made responsible for the grant application to make the iSFP. They can also inform building owners about other financial support programmes offered by the German federal government [2]. To facilitate the use and implementation of the tool, the ministry is working closely together with the developers of accounting software in the construction industry to integrate the tool in the software already used by architects and other construction industry professionals [5]. Furthermore, the add-on module in this software can be updated based on feedback from professionals in the field, as happened in 2020 [6]. In principle the degree of transferability of the idea and methods behind the iSFP is high.
Matching EU policy framework	EPBD Article 11 – energy performance certificates. The Commission could consider complementing article 11 and include (part of) the integral elements of the iSFP as requirements for the EPC. Renovation Wave initiative. The clear information provision and coordination integrated in the iSFP could help increase the renovation rate in the EU and thereby achieve the targets of the Renovation Wave. EED Article 17 – information and training. The iSFP is a policy instrument that can support Member States to provide information to citizens about the practicalities and benefits of making energy efficiency improvements.
Costs	For 2014-2018 (Energy Advice for Residential Buildings) total costs were €32.2M, of which €25.6M was for consultations and €6.7M for programme management [7]. No specific figures were found for the development of the iSFP.
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	• Upgrade of urban context – The iSFP stimulates residential building owners to renovate their buildings which might result in the **upgrade of the urban context** surrounding the building. Within the evaluation of the iSFP one suggestion for improvement related to the inclusion of a comfort indicator to the schedule [9]. The inclusion of such an indicator could **improve health and wellbeing.**
Lessons learned	• Success factors, strength and opportunities – The integration of iSFP in calculation software for building sector professionals facilitates

	implementation, which can be considered a success factor. The ease of use for building owners is high because the auditors are responsible for applying for funding. • Challenges of implementation (weaknesses and threats) – There is no comfort indicator in the current iSFP, which should be included [9]. – The grant for the energy audit was increased from 60% to 80% in 2020 to further increase the uptake of the iSFP [10].
Synergies	**Financing renovation** – once building owners know which steps they can take, access to financing is essential to stimulate investments in renovation.
Bibliography	[1] DENA (2017). "Individueller Sanierungsfahrplan unterstützt Hauseigentümer bei Modernisierung". Deutsche Energie-Agentur. Link. [2] BMWi (n.d.). "Deutschland-machts-effizient". Federal Ministry of Economic Affairs and Energy. Link [3] FEBS (n.d.). "Methodology of the iSFP". Federal Office for Economics and Export Control. Link [4] BWA (n.d.). "Bundesförderung für Energieberatung für Wohngebäude". Federal Office for Economics and Export Control. Link [5] DENA (n.d.). "Individueller Sanierungsfahrplan für Wohngebäude". Deutsche Energie-Agentur. Link [6] FEBS (2020). "Upgrade des individuellen Sanierungsfahrplans – iSFP 2.0 steht ab jetzt für Haussanierungsvorhaben und Energieberater zur Verfügung". Federal Office for Economics and Export Control. Link [7] PwC (2019). "Evaluation der Energieberatung für Wohngebäude" Link [8] BAFA (n.d.). "Gegenüberstellung der Richtlinien 2017-2020". Federal Office for Economics and Export Control. Link. [9] DENA (2018). "Pilotproject zur Einführung des individuelles Sanierungsfahrplans". Deutsche Energie-Agentur. Link [10] FEBS (2020). "Förderung Energieberatung". Federal Office for Economics and Export Control. Link.

7.7 New York City (USA) – Building Emissions Law

<table>
<tr><td>Policy/initiative</td><td>NYC Building Emissions Law</td></tr>
<tr><td>Location</td><td>Local level – United States of America</td></tr>
<tr><td>Start year</td><td>2019</td></tr>
<tr><td>Building types</td><td>Residential buildings</td></tr>
<tr><td>Status</td><td>Enacted</td></tr>
<tr><td>Type of policy</td><td>Regulation</td></tr>
<tr><td>Short description</td><td>The Building Emissions Law (Local Law 97) is a mandatory minimum requirement which sets maximum carbon intensity limits (max $CO_2/m^2/y$) specified to building segments [1].

The policy focuses on larger buildings (>7,600m^2) and affects 50,000 residential and non-residential buildings [2]. The final aim is to reduce city-wide emissions from buildings by 80% in 2050 [4].

In 2030 the law should have resulted in an emission reduction of 40% from a 2005 baseline [5].</td></tr>
<tr><td>Primary energy savings</td><td>No concrete numbers of primary energy savings are provided.</td></tr>
<tr><td>CO_2 emission savings</td><td>In 2005 NYC had approximately 62 $MtCO_2$-eq emissions [6]. In 2030 roughly 24.8 $MtCO_2$ (40%) should be reduced, and in 2050 this should be reduced by 49.6 $MtCO_2$-eq (80%).

The table below describes the emission reduction targets per building segment [7]

<table>
<tr><td rowspan="2">Occupancy group</td><td colspan="2">Carbon limit – kg CO_2e/</td></tr>
<tr><td>2024-2029</td><td>2</td></tr>
<tr><td>A – Assembly</td><td>10.74</td><td>4</td></tr>
<tr><td>B – Business</td><td>8.46</td><td>4</td></tr>
<tr><td>E and I-4 – Educational and institutional custodial care facilities</td><td>7.58</td><td>3</td></tr>
<tr><td>I-1 – Institutional supervised living and personal care facilities</td><td>11.38</td><td>5</td></tr>
<tr><td>F – Factory and industrial</td><td>5.74</td><td>1</td></tr>
<tr><td>B civic administrative facility for emergency response services, B non-production laboratory, Group B ambulatory health care facility, H, I-2 or I-3</td><td>23.81</td><td>1</td></tr>
<tr><td>M – Mercantile</td><td>11.81</td><td>4</td></tr>
<tr><td>R-1 – Transient residential buildings</td><td>9.87</td><td>5</td></tr>
<tr><td>R-2 – Residential</td><td>6.75</td><td>4</td></tr>
<tr><td>S and U – Storage</td><td>4.26</td><td>1</td></tr>
</table></td></tr>
<tr><td>Increased renovation rate and depth</td><td>No specific renovation rates or depths are mentioned.</td></tr>
<tr><td>Ease of implementation</td><td>The Local Law 97 is part of a larger overall policy framework called the Climate Mobilisation Act. Besides the cap on emissions for large buildings, assessments will be made to evaluate if heat supply can be</td></tr>
</table>

	made sustainable and roofs of buildings will need to become green roofs or be filled with solar panels [3]. Another law that facilitates the implementation of Local Law 97 is the NYC Benchmarking Law, which obliges building owners of large properties to annually report on their water and energy usage in the ENERGY STAR portfolio management system [2]. This data is used to identify if emission reductions are achieved. Local Law 33 elaborated on the benchmarking law, giving each building a grade with an obligation for building owners to display this grade visibly in the building [2]. If building owners do not comply, high penalties are enforced, equalling US$268 per tonne of CO_2 per year [5].
Matching EU policy framework	N/a
Costs	Costs for the NYC administration were not found. Costs for building owners depend on the conditions of their property.
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	This policy leads to an upgrade of the urban context.
Lessons learned	• Success factors, strength and opportunities – Term targets provide clarity to building owners. – Carbon cap leaves owners freedom to choose the most suitable solutions. – The high fines will stimulate building owners to invest – Emission reductions can also be achieved by energy efficiency measures, which reduces the bills – Linked to already existing policies like the NYC benchmarking law • Challenges of implementation (weaknesses and threats) – Certain building owners that have already made efforts to reduce the environmental footprint of their buildings still do not comply with the targets [5]. These building owners might have to increase the rent to earn back their investments in energy renovations.
Synergies	n/a

Bibliography	[1]https://www.urbangreencouncil.org/content/nyc-building-emissions-law-frequently-asked-questions [2] https://www1.nyc.gov/html/gbee/html/plan/ll84.shtml [3] https://council.nyc.gov/data/green [4] https://laws.council.nyc.gov/legislation/int-1253-2018 [5]https://codegreensolutions.com/nyc-carbon-emissions-bill-passed-into-law-local-law-97-what-it-means-for-commercial-building-owners/#:~:text=On%20May%2018th%20Intro%201253,2030%20from%20a%202005%20baseline. [6] Link [7] https://www.globest.com/2019/08/27/a-deeper-dive-into-nycs-climate-mobilization-act-and-local-law-97/?slreturn=20200717041014

7.8 Denmark – Better Home programme

Policy/initiative	Bedre Bolig
Location	National level – Denmark
Start year	2014
Building types	Residential buildings
Status	Enacted
Type of policy	One-stop-shop
Short description	In 2015 a law was adopted by the Danish government that allows the establishment of one-stop-shops. These enable companies to map building energy saving options, identify the impact of these options on the energy performance of the building, draft plans for how energy performance can best be improved, and introduce building owners to companies who can implement these measures [1]. The Danish Energy Agency subsequently launched the Bedre Bolig (Better Housing) scheme in 2016 [2]. The initial plan was to create a market-based mechanism without much public support. The Bedre Bolig scheme offered building owners the opportunity to buy a renovation plan based on the inspection and advice of a qualified expert [3]. The plan includes information about energy performance, renovation steps, energy efficiency priorities, advice on energy efficient living and behavioural change and a total renovation budget and investments required [3].
Primary energy savings	No primary energy savings have been recorded in the evaluation.
CO_2 emission savings	No CO_2 emission savings have been found.
Increased renovation rate and depth	No detailed data is available on the increase of renovation depth [3].
Ease of implementation	The principle of one-stop-shops is relatively easily transferable to other countries. The Danish Ministry of Climate, Energy and Buildings implemented a Bedre Bolig awareness campaign [3]. The Danish Energy Agency is responsible for the operation of the Bedre Bolig scheme [2]. Qualified professionals and construction companies are responsible for the design and implementation of the renovation measures.
Matching EU policy framework	• Renovation Wave
Costs	€2.015 million [3]
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including	Upgrade of the urban context

enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	
Lessons learned	• Success factors, strength and opportunities – Homeowners that bought a Bedre Bolig plan generally implemented more "innovative" renovations [3]. – 400 qualified experts have been trained to provide advice and write Bedre Bolig renovation plans [3] • Challenges of implementation (weaknesses and threats) – In the view of the Danish government the programme did not live up to the initial expectations due to the relatively low amount of renovations (2016). A major reason is that homeowners are not used to paying for renovation advice [3]. Municipalities stepped in and provided many with up to 50% of the cost, which stimulated many to invest in a Bedre Bolig plan. – Initially there was also no digital database set up to record the amount of Bedre Bolig renovation plans sold. – The homeowners that implemented renovation measures were less interested in energy savings and more in health, comfort and wellbeing. The Danish government could have better tailored their national awareness campaign to these issues instead of energy efficiency [3]. The campaign should also be more tailored to homeowners experiencing changes in life (e.g. having children, children leaving home, etc.). – An evaluation report from 2016 indicates that it should be clarified whether the programme is solely market-based or complemented by other (financial) schemes offered by Danish municipalities [3].
Synergies	**Financing renovation** – the success of a one-stop shop partially depends on how easy it is for building owners to get access to financing, which ideally is the one-stop-shop can facilitate.
Bibliography	[1] https://www.retsinformation.dk/eli/lta/2015/1876 [2] https://sparenergi.dk/forbruger/vaerktoejer/bedrebolig [3]https://ec.europa.eu/docsroom/documents/30288/attachments/3/translations/en/renditions/pdf

7.9 *Ireland - Better Energy Communities*

Policy/initiative	Better Energy Communities scheme (community energy grant)
Location	Ireland
Start year	2012
Status	Ongoing
Building types	Residential, non-residential, and public buildings in a community
Type of policy	Grant
Short description	The Irish community grant scheme "Better Energy Communities" offers €20 million of funding (for 2020) to support energy efficiency upgrades with €50,000 to €1,500,000 per project across building types that reduce energy consumption and achieve various benefits throughout the community. The scheme aims at demonstrating (large-scale) renovation project models that use innovative approaches and can easily be replicated. Projects are selected based on a point-scoring system (minimum of 65 marks to be eligible) and assessed on a first-come, first-served basis. Evaluation criteria are value for money (max. 40 marks), community and partnership approach (max. 35 marks) and quality and delivery (max. 25 marks). The scheme, implemented by the Sustainable Energy Authority Ireland (SEAI), supports insulation measures, renewable energy installations as well as technology and system upgrades that are integrated in comprehensive community projects and innovative and ambitious targets (single measures are not supported). The scheme focuses on community-based partnerships between homeowners, communities, and private sector organisations, such as member of the SEAI's Sustainable Energy Community (SEC) network. Single homeowners cannot apply, and beneficiaries should cover different sectors (domestic, private, public, not-for-profit). Members of the SEC network have advantages in the evaluation process [1][2].
Primary energy savings	2019 €25.3 million government funding invested; €40.5 million private resources mobilised to reach €65.8 million total project costs [5] 4.8 kWh per Euro of public investment in 2019 Programme up to now 122.5 GWh total energy credits saved (energy credits under the energy efficiency obligation scheme) [5]
CO_2 emission savings	34,676 t CO_2 emissions reductions annually (2012-2019) [5] In 2017 CO_2 emissions of the Irish building sector amounted to 7.7 Mt, so the savings represent roughly 0.45%. According to the Climate Action Plan (2019) the indicative 2030 building sector target is to emit max. 5 Mt CO_2. [6]
Costs	€25.3 million public funding in 2019, €21 million public funding in 2020 €65.8 million total project costs No information on renovation or administrative costs
Increased renovation rate and depth	Cumulatively the programme has now supported upgrades in 18,200 homes and 2,570 non-domestic buildings [5] No information on renovation rate.

Ease of implementtation	• Transferability: the scheme design can be transferred to other countries and is not limited to one climate zone. As it already supports multiple building types the degree of transferability is high. • Administration: administered at national level by SEAI; administrative costs are shared with other grant schemes (all managed by SEAI, share code of practice and list of qualified contractors) • Compliance checks: pre- and post EPCs (Building Energy Rating, BER) are required for all upgraded buildings; minimum BER after the renovation works is C1 (preferably B2); works must comply with Part L of the building regulations and Better Energy Homes Scheme Contractors Code of Practice, QADP (Quality Assurance and Disciplinary Procedures), Standards and Specification Guidelines; M&V requirements [1]. • Complementary measures: – The community grant scheme is part of the Better Energy Homes schemes which funds energy efficiency upgrades of the Irish building stock. The scheme follows the same guidelines and must meet the standards of the Building Regulations Part L (Conservation of Fuel and Energy). If a heat pump system is installed as part of a community project the heat loss indicator requirements of the heat pump grant needs to be followed [1], [12] – The SEC is a SEAI network initiative accompanying the community grant to accelerate the exchange between communities and learn from each other. SEC members are prioritised in the grant application phase[1]. – The scheme design recommends cooperation with a participating energy supplier under the energy efficiency obligation scheme to trade their amount of energy saved (1 kWh saved equals one energy credit) for support in the form of project management, financial contribution, provision of materials, installation of works, monitoring, energy audits or advice [1].
Matching EU policy framework	As a grant scheme, the community energy grant could be integrated as a good practice policy for other financial schemes on national level or funding criteria of the EU ESI funds [7]. It could also provide good examples for the Community-led Local Development programme of the European Structural and Investment Funds [8]
Addressing • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (incl. climate resilience) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (incl.	• The grant scheme supports residential projects of residents at **risk of energy poverty** with a special focus (up to 80% of the costs for energy-poor households, overall level of support only 50%) [1] • **Improve health and wellbeing**: see case studies on healthier and more comfortable homes (SEAI, 2018) [3], no exact numbers available • **Secure fair transition**: programme beneficial to a broad range of stakeholders

access to sustainable mobility)	
Lessons learned	• Success factors, strength and opportunities – Community approach (benefits for the larger community) – Fabric-first approach (prevents oversized supply-side measures (e.g. heat pumps) being implemented) [4] – Supporting innovative approaches (demonstration projects to test and implement new business models and technologies) [1] • Challenges of implementation (weaknesses and threats) – Product manufacturers proposing projects which focused on their products (supply-side options) rather than what is necessary for the homes in question (reason to implement the fabric-first approach) – Requirement of B2 BER after the intervention makes compliance with application criteria harder
Synergies	The community-oriented approach of the grant scheme supports innovative, large-scale projects, creating synergies with the **district approach** policy area. The community grant also impacts the area of **financing renovation** as it unlocks financial means for end-users (including a higher share of funding for energy-poor users). The eligible criterion of a sustainable financing model ensures that applicants have the financial resources in place to complete their project. The application guidelines of the grant scheme additionally require the applicants to adopt smart technologies as appropriate which might lead to increased digital technologies and smart building systems implemented and creates synergies with the **digital technology** area.
Bibliography	[1] SEAI (2019). Communities Energy Grants Application Guidelines 2020. Sustainable Energy Authority of Ireland [2] SEAI (2018a). Better Energy Communities Application Guidelines 2018. Sustainable Energy Authority of Ireland. [3] SEAI (2018b). How communities are working together to save energy. Case Study report, Sustainable Energy Authority of Ireland. [4] SEAI (2017). Better Energy Communities Application Guidelines 2017. Sustainable Energy Authority of Ireland Web sources: [5] SEAI webpage about the grants of the Better Energy Communities scheme: https://www.seai.ie/grants/community-grants/project-criteria-and-funding [6] Climate Action Plan 2019, Ireland https://www.dccae.gov.ie/en-ie/climate-action/publications/Documents/16/Climate_Action_Plan_2019.pdf [7] Common Provisions on EU funds, EU 1303/2013 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R1303&from=EN [8] EU Commission, Guidance for Member States and Programme Authorities on Community-led Local Development in ESI Funds https://ec.europa.eu/regional_policy/sources/docgener/informat/2014/guidance_community_local_development.pdf

7.10 France – Picardie Renovation Pass

Policy/initiative	Picardie Pass Rénovation (Picardie Renovation Pass)
Location	Regional
Start year	2013
Building types	Residential (single-family buildings, multi-family buildings, etc.)
Status	Ongoing
Type of policy	One-stop shop
Short description	The Picardie Pass offers building owners an integral service including energy performance advice, technical support, financial support, monitoring and links to construction professionals [1]. The management team of the Picardie Pass takes responsibility for payment of the companies, collection of the subsidies and setting out a tender for the renovation amongst construction companies. Residents start paying a fixed monthly reimbursement for a duration ranging between 10 and 25 years with 2% interest rate [2]. Funding for the Picardie Renovation Pass is derived from the European Investment Bank (EIB), Interreg and the Region of Picardie. The programme aims to reduce primary energy consumption by 40-75% [1].
Primary energy savings	18.25 GWh/y [3] - 45 GWh/y [2]
CO_2 emission savings	3,400 tCO_2/y [3] – 6,000 tCO_2/y [2]
Increased renovation rate and depth	45% real energy savings per building on average [1]
Ease of implementation	A regional public service company has been created to administer the implementation of the Picardie Pass. The "Régie Régionale du Service Public de l'Efficacité Energétique (SPEE) en Picardie" has 14 employees and collaborates with external partners in the construction sector and administrative sector [3]. Final investments are based on the results of energy audits as a form of compliance check.
Matching EU policy framework	The Picardie Rénovation Pass could contribute to achieving the targets of the **Renovation Wave**.
Costs	Total estimated costs of the project were €54.4M, of which €45.4M was for the renovation activities and €9M for planning and administration [2]. Real costs turned out to be €35M for renovation measures. Division of costs for an average financial renovation package: 13% subsidies, 17% self-financing, 70% third-party financing [2]. Average investments were €42,000 for single-family houses, and €15,350 for apartments [3]. A leverage factor of 20 was achieved [3].
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment	The Picardie renovation programme helps to **upgrade the urban context** in the region Hauts de France due to the renovation of mostly old buildings constructed before 1975. The Picardie renovation programme helps to achieve a **fair transition** because it resulted in 372 FTE, mostly local jobs [2][3].

(including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	
Lessons learned	• Success factors, strength and opportunities – Technical support is highly appreciated by end-users [2]. • Challenges of implementation (weaknesses and threats) – Very old buildings are difficult to renovate due to the limited amount of qualified companies, difficult cost estimations and generally higher costs and longer renovation duration [2] – Non-technical support, e.g. administrative support, for companies and end-users is underestimated but necessary to assure all actors know their role in the supply chain [2] – Technical issues often occur related to the quality of the renovation measures and airtightness of the building. Consequentially, more measures may become necessary [2] – Organisational and administrative difficulties occur related to communication between actors in the supply chain and related to receiving invoices and technical drawings and incorporating additional requests from residents [2] – Renovating multi-apartment buildings is a lengthier process than single-family buildings [3] – The Hauts de France region is completely responsible for the development and financial risks of third-party financing. Even if the risks prove manageable, further financial structuring should be pursued, e.g. by limiting third-party financing or a debt assignment mechanism to limit borrowing from the EIB [3].
Synergies	The Picardie Renovation Pass also relates to the strategic area of **financing renovation**. If designed properly and all actors collaborate, the policy could lead to increased funding available for building renovation.
Bibliography	[1] SPEE (2019). "La Service public de l'efficacité énergétique des Hauts-de-France". Region Hauts de France. Link http://www.planbatimentdurable.fr/IMG/pdf/dp-bilanforumspee-fev2019.pdf [2] Morcrette, A. (2018). "Experimental deployment of Picardie Pass Rénovation". Picardie Renovation Pass. Link [3] EIB (2018). "ELENA Completed Project Factsheet – Picardie Renovation Pass". European Investment Bank. Link

7.11 Romania – National Thermal Rehabilitation Programme

Policy/initiative	National Thermal Rehabilitation Programme
Location	National level - Romania
Start year	2009
Building types	Residential buildings (Condominiums)
Status	Enacted
Type of policy	Grant
Short description	The National Thermal Rehabilitation Programme is based on grants for condominium associations to improve energy efficiency and wellbeing [1]. The objective of the programme is to reduce greenhouse gas emissions and improve environmental, health and economic value in urban areas. Condominium associations have to pay 20% of the costs, the other 80% is paid by local and state budgets [1]. The program was initiated in 2009, and in 2020 the new multi-annual budget for the programme from 2020 – 2022 was approved [2]. Renovation measures related to the building shell, the heating systems and the hot-water supply are eligible [5].
Primary energy savings	No information was found for the period from 2009-2014. From 2014-2020 the programme resulted in CO_2 emissions equal to 0.7 Mtoe (11,630 GWh) [3].
CO_2 emission savings	No information available
Increased renovation rate and depth	No information available
Ease of implementation	50% of the funding comes from the state budget through the Ministry of Regional Development and 30% of the costs come from local government budgets [1]. Besides the grant programme, there is a thermal renovation loan programme that provides low-interest financing options for energy performance renovations [4].
Matching EU policy framework	• Renovation Wave
Costs	Funding is allocated per building blocks in specific regions and accounts for €10 million (2020-2022) (assuming the budget is expressed in Romanian Leu) [6]
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building)	Upgrade of the urban environment

• Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	
Lessons learned	• Success factors, strength and opportunities – The high grant ratio encourages condominium associations to apply for the programme. • Challenges of implementation (weaknesses and threats)
Synergies	
Bibliography	[1] https://www.mlpda.ro/pages/pncrestereperformanta [2]http://lexcafe.ro/2020/06/15/a-fost-aprobat-programul-national-multianual-privind-cresterea-performantei-energetice-a-blocurilor-de-locuinte [3]https://ec.europa.eu/energy/sites/ener/files/documents/ro_neeap_ro.pdf [p33] [4]https://ec.europa.eu/docsroom/documents/29812/attachments/4/translations/en/renditions/native [5] http://legislatie.just.ro/Public/DetaliiDocument/103284 [6] https://lege5.ro/Gratuit/gm3tinbsg44a/ordinul-nr-2154-2020-pentru-aprobarea-programului-national-multianual-privind-cresterea-performantei-energetice-a-blocurilor-de-locuinte-cu-finantare-in-perioada-2020-2022

7.12 Portugal – Energy Certification of Buildings

Policy/initiative	Certificação Energética dos Edifícios – Energy Efficiency Certification of Buildings
Location	National level
Start year	2007
Building types	Residential and non-residential
Status	Ongoing
Type of policy	Energy performance certification scheme
Short description	The Energy Efficiency Certification of Buildings scheme aims to improve energy performance, health and comfort [1]. Buildings receive a rating ranging from F to A+. The digital certificate specifies how the EPC affects categories like comfort, health, and energy consumption of hot water and air conditioning [1]. EPCs in Portugal are issued by qualified experts that also suggest customised renovation measures to building owners to improve the energy performance and comfort of their properties. Different requirements apply to EPCs for buildings in the residential and non-residential sector [2]. EPC requirements apply for all new buildings and existing buildings. In case of sale, rent or major renovation, a valid EPC must be presented. If a building does not have an EPC before a renovation or construction, a provisional EPC is formulated. This provisional EPC must be validated after the renovation/construction is finished [2]. Developers and real estate agents are also obliged to display the EPC in advertisements, in addition to all large building owners (>1000m^2) [4]. The scheme's website provides a clear overview with national statistics including the ratio of EPC scores in all Portuguese regions and the amount of measures implemented [3].
Primary energy savings	No specific information about the impact of EPCs on primary energy savings has been found.
CO_2 emission savings	No specific data on the impact of EPCs on CO_2 emission savings has been found.
Increased renovation rate and depth	No specific information about the increase in renovation rate or depth of renovation was found.
Ease of implementation	Energy efficiency certification schemes already exist in multiple European Member States, which suggests that the transferability of the measure is high. One issue could be the public display of EPC data, which might be more difficult in countries that prioritise data protection [9]. The policy is administered by ADENE, the Portuguese Energy Agency [7]. Compliance checks exist for the experts doing the EPCs. These professionals must be architects or engineers with at least five years' experience in the field of energy efficiency and pass an exam of ADENE [6]. Non-compliance of experts can be penalised with fines.
Matching EU policy framework	The scheme is complemented by other policy initiatives. These include the energy labelling of installations and products with the voluntary CLASSE+ certification and the online portal casA+. CLASSE+ indicates how energy efficient building products are (e.g. installations, windows, etc.). casA+ functions as a one-stop-shop and centralises all relevant information on the building in one accessible location besides providing building owners with potential renovation measures [1].

Costs	Revenues for the EPC scheme outweighed the costs of administration in 2018 and 2019 [7]. This could be related to the registration costs that need to be paid to put the EPC in the ADENE database, ranging between €35-65 for residential buildings and €2-5/m² for non-residential buildings. This registration fee is included in the EPC price and functions as income for ADENE [8]. Costs for building owners that want to obtain an EPC range between €135 - €465 [6].
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	The EPC displays building information related to **health and wellbeing** in addition to energy performance, nudging building owners e.g. to improve indoor air quality.
Lessons learned	• Success factors, strength and opportunities – High uptake of EPCs, with more than 1.3 million EPCs issued and 15% of the building stock covered [6]. – Centralised database that provides insight into national and regional building performance and generates awareness amongst building owners and tenants. – Links with other policy programmes like casA+ and CLASSE+ that enhance public awareness about energy efficiency. • Challenges of implementation (weaknesses and threats) – Lack of awareness amongst building owners [5] – Financial concerns related to energy efficiency [5] – Training sufficient qualified experts that can perform energy audits [5] – Privacy issues related to public EPC databases [9] – The calculation methodology of the energy certification scheme has changed drastically in the past 10 years. As a result, buildings that were certified in 2010 will receive a significantly different score in terms of primary energy use and emissions. This might cause confusion about actual energy performance and might deteriorate trust in the rating [10].
Synergies	The digital EPCs linked to online platforms like casA+ rely on digital infrastructure and contribute to the **digitalisation** of the building sector.
Bibliography	[1] https://www.adene.pt/edificios [2] https://www.buildingrating.org/jurisdiction/Portugal

	[3] https://www.sce.pt/estatisticas [4] https://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-portugal.pdf [5] http://ccap.org/assets/CCAP-Booklet_Portugal.pdf [6] http://ibroad-project.eu/wp-content/uploads/2018/01/iBROAD_CountryFactsheet_PORTUGAL.pdf [7] https://www.adene.pt/Files/flipbook/ADENE-PAO-2019-2021/mobile/index.html [8] http://www.buildup.eu/sites/default/files/content/ca3-2016-national-portugal-web.pdf [9] https://www.epbd-ca.eu/outcomes/2011-2015/CA3-CT-2015-1-Certification-web.pdf [10] https://www.sciencedirect.com/science/article/pii/S235248471930472X

7.13 Poland – Catching Up Regions programme

Policy/initiative	Catching Up Regions programme
Location	Regional level (Poland)
Start year	2016
Building types	Single-family buildings
Status	Abandoned
Type of policy	Targeted subsidies and tax incentives
Short description	The objectives of the policy were to reduce air pollution and improve energy efficiency of single-family buildings [1]. The Malopolskie and Śląskie regions were identified for a programme of thermal retrofitting and replacement of heating systems. These regions were selected due to the significant environmental pollution present, partially caused by inefficient fossil fuel heating systems [1]. The World Bank was commissioned by the European Commission to support the government of Poland in the design of financial instruments to replace non-compliant solid fuel boilers and energy efficiency retrofits of single-family buildings [1]. The World Bank involvement in the project had two phases – phase one ended in 2017 [1] and the second phase was in 2018-2019 [2]. During the first phase consensus amongst the local stakeholders resulted in the strategy to develop two tools [1]: 1) Public and financial support for poor single-family buildings with 90-100% subsidy with municipal monitoring and administration 2) Commercial financial instruments to support non-poor single-family buildings including 20% subsidies and fiscal incentive mechanisms.
Primary Energy savings	The potential savings for the regions are: 2.14 TWh/year (poor single-family buildings) and 11.38 TWh/year (non-poor single family buildings [1]
CO_2 emission savings	The potential savings for the regions are: 451,884 tCO_2/year (poor single-family buildings) and 2,403,576 tCO_2/year (non-poor single-family buildings) [1]
Increased renovation rate and depth	No information found
Ease of implementation	The energy efficiency and anti-smog renovation programme was part of a broader programme of not directly related activities in Poland, which included food inspection practices, establishing an innovation centre and improvement of spatial planning [2]. The programme was a pilot project in the EU-wide "Catching Up" initiative [4]. The Malopolskie and Śląskie regions had previously implemented anti-smog regulations in order to phase out inefficient heating systems [1]. The World Bank maintained a strong coordination team, and collaborated with a multidisciplinary and autonomous team of experts that had regular contact with local (regulatory) stakeholders in Poland [1]. Furthermore, the European Commission monitored the progress and acted as a facilitator at times of tension.
Matching EU policy framework	Renovation Wave

Costs	Costs for the design of the plans were not found. Implementation of the plan for poor SFBs would range between €0.7–1.1 billion and between €4-6 billion for the non-poor SFB [1].
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	An explicit aim of the renovation programme was to improve the **health and wellbeing** of Polish residents. **Securing a fair transition** by providing poor single-family buildings subsidies.
Lessons learned	• Success factors, strength and opportunities – Collaboration with local stakeholders [1] – Integration of the programme with existing policies [1]
Synergies	**Financing renovation** is essential to implement these plans.
Bibliography	[1] http://documents1.worldbank.org/curated/en/658171529401377521/pdf/127333-WP-P131821-PUBLIC-envsingleweb.pdf [2]https://www.worldbank.org/en/country/poland/publication/catching-up-regions [3]http://documents1.worldbank.org/curated/en/321551561356314044/pdf/Poland-Catching-Up-Regions-3-Overview-Report.pdf [4]https://ec.europa.eu/regional_policy/en/policy/how/improving-investment/lagging_regions http://documents1.worldbank.org/curated/en/628751529413212282/pdf/WP-P131821-PUBLIC-POLISH-plvsingleweb.pdf

7.14 Ireland - ProEnergyHomes

Policy/initiative	ProEnergy Homes
Location	National level - Ireland
Start year	2018
Building types	Residential buildings
Status	Enacted
Type of policy	
Short description	A one-stop-shop initiative of the Sustainable Energy Agency Ireland (SEAI) in collaboration with private credit unions. The scheme includes building-specific energy advice by a qualified expert on renovation actions and low-interest renovation loans that can be supplemented with a grant of up to 35% from the SEAI [1]. After a pilot in 2018 with five participating credit unions in Dublin, the programme was expected to increase the amount of implemented renovation measures 10-fold for a loaned amount of €10 million [3]. The payback period is often short. For many cases net savings can be achieved within 5-7 years while having an improved and healthier living environment [3].
Primary energy savings	No information found
CO_2 emission savings	No information found
Increased renovation rate and depth	No specific information provided
Ease of implementation	The scheme is implemented by The Solution Centre (a strategic development unit for credit unions), the SEAI, Retrofit Ireland (REIL) and 20 participating private credit unions [2]. The Solution Centre ensures there is a dedicated project manager to support applicants with each step in the renovation process, from applying to funding to the implementation of the renovation measures. Retrofit Ireland ensures that an energy audit is performed while SEAI provides a grant and the credit unions ensure that low interest financing is available [2].
Matching EU policy framework	Renovation Wave
Costs	The average loan in the pilot phase was €10,000 and total investment costs around €15,000 [2].
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced	Upgrade of the urban context

resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	
Lessons learned	• Success factors, strength and opportunities – The successful pilot indicates demand for the programme. – Public-private partnership with public and private knowledge and funding [1]. – Building owners indicate that they would now consider renovation while they did not do this before [2]. – Energy renovation is made very easy for building owners, who only have to fill in an application form and approve the plan made by REIL [2].
Synergies	**Financing renovation** is part of what makes the services of this one-stop-shop attractive for building owners.
Bibliography	[1]https://proenergyhomes.ie [2]https://www.solutioncentre.ie/2019/05/13/credit-unions-team-up-with-seai-reil-to-provide-pro-energy-homes-scheme [3] https://www.irishtimes.com/business/financial-services/credit-unions-to-loan-up-to-10m-for-home-energy-upgrades-1.3889800

7.15 Sweden – Carbon tax

Policy/initiative	Carbon tax (Koldioxidskatt)
Location	National – Sweden
Start year	1991
Building types	Residential and non-residential
Status	Ongoing
Type of policy	Regulation – Tax
Short description	The Swedish carbon tax is levied on combustion of fossil energy carriers [1]. The tax is based on the carbon content of the fuel because the emissions are proportional to the carbon content. As such, it is not necessary to measure the actual emissions. Sustainable biofuels are not taxed [1]. Since the carbon tax was introduced in the 1990s it has increased from €23 to €110/tCO_2 in 2020. All economic sectors outside of the electricity sector are covered by the tax [3]. Emissions in the building sector are subject to the carbon tax, which has resulted in significant emission reductions [3]. These reductions were mostly achieved by a change in fuels (from fossil to sustainable biomass and electricity), scaling up district heating systems and electrification of heat sources.
Primary energy savings	
CO_2 emission savings	Emissions for heating have decreased by 80% since the introduction of the carbon tax in 1991 [3].
Increased renovation rate and depth	No information about renovation depth.
Ease of implementation	The transferability of the policy is high, especially if Member States already have systems of energy or fuel taxation in place [1]. The carbon tax is part of a wider set of environmental policies including the energy tax, the VAT on energy, and taxes for nitrogen oxide and sulphur [3]. Close interlinkages exist with the energy tax, where increases in the carbon tax are synchronised with reductions of the energy tax. This reduces the increase of the overall tax burden but simultaneously provides customers with a clear price signal for carbon usage [3].
Matching EU policy framework	Renovation Wave
Costs	In 2017, the *revenues* of the carbon tax were €2.4 billion. Combined with the energy tax the total revenues accounted for €7.2 billion [3].
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced	Increase sustainable infrastructure in built environment

- resilience of building) - Increase smart readiness of buildings - Secure fair transition - Upgrade of urban context (including access to sustainable mobility)	
Lessons learned	Success factors – Low administrative costs for the authorities [1] – Simple design and common units (carbon content) for calculation of tax rates facilitated monitoring, evaluation and compliance [2]. – Significant exemptions were provided to industries to reduce double-taxing and protect competitiveness [2]. These exemptions did not, however, result in missing significant abatement opportunities and improved the cost-effectiveness of the tax [3]. Additional exemptions were provided based on geographic and social grounds [2]. – Public acceptance and support for high tax rates are present in Sweden, while adverse economic impacts have been reduced by strategic exemptions [3]. – The carbon tax has succeeded in increasing demand for alternative fuels [2].
Synergies	n/a
Bibliography	[1] Government Offices of Sweden (2020). "Sweden's carbon tax". Link [2] https://es.catapult.org.uk/wp-content/uploads/2018/10/Sweden-Case-Study-FINAL.pdf [3] https://www.euki.de/wp-content/uploads/2018/09/fact-sheet-carbontax-se.pdf

7.16 Scotland – Historic Environment climate action plan

Policy/initiative	Historic Environment climate action plan 2020-25
Location	Regional level – Scotland
Start year	2020
Building types	Cultural heritage
Status	Enacted
Type of policy	Initiative
Short description	Strategic action plan from Historic Environment Scotland (HES), the public body responsible for research into and maintenance of historic sites in Scotland [1]. The plan addresses seven priority areas for the management and preservation of historic sites, of which one relates to energy and carbon management [1]. This includes the target to become "net-zero" in 2045, elimination of gas heating and transition to 100% renewable heat in 2032, historic sites as energy hubs in populated areas, and the improvement of energy efficiency of all sites. The plan also sets out targets and goals in relation to climate change adaptation, circularity, biodiversity and landscapes. HES annually invests in many conservation and renovation projects in Scotland [2].
Primary Energy savings	No information found.
CO_2 emission savings	No information was found on the CO_2 emission reductions from the climate action plan. However, over the period 2015-2019 GHG emissions dropped by 23% [2].
Increased renovation rate and depth	No information found.
Ease of implementation	Historic Environment Scotland is responsible for the implementation of the strategy. HES is a non-departemental public body that manages over 300 historic sites of national and cultural importance. The board is appointed by Scottish ministers. Next to the climate action plans, HES is running an overarching strategy for cultural heritage, "Our Place in Time". The wider policy framework includes important laws like the Climate Change Act (2009), the Climate Change (Emission Reduction Targets)(Scotland) Act 2019, Our Place in Time, the Historic Environment Strategy for Scotland (2014-2024), the Historic Environment (Scotland) Act 2014, the Climate Change (Duties of Public Bodies: Reporting Requirements)(Scotland) Order 2015 and Scotland's National Performance Network [1]. The transferability of the programme depends on the governance structures for cultural heritage in place in other Member States. Compliance is checked because HES produces annual reports with the yearly environmental performance [2].
Matching EU policy framework	Renovation Wave EU European Heritage Strategy for the 21st Century
Costs	Costs for the implementation still have to be calculated [1].

	In 2018-19 HES invested £7,8 million in its own properties and provided £14.5 million in grants for renovation/restauration and archaeology [1].
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	Secure a fair transition Increased sustainable infrastructure in the built environment (including climate resilience).
Lessons learned	• Success factors, strength and opportunities – Many measures in the plan make financial sense by offering cost-reduction potential, e.g. through reduced waste, travel and energy use [1]. At Edinburgh Castle, for example, a £480,000 investment in energy efficiency reduced final energy consumption by 30% and emissions by 40% and had a payback time of five years. – Improving the climate resilience of cultural heritage helps to avoid high financial costs in the future [1]. • Challenges of implementation (weaknesses and threats) – It is a challenge for HES to reduce emissions and impact while simultaneously having to facilitate and welcome increasing numbers of visitors to cultural heritage buildings [1]. – Climate change makes managing vulnerable buildings and landscapes more costly and complex [1].
Synergies	
Bibliography	[1]https://www.historicenvironment.scot/archives-and-research/publications/publication/?publicationId=94dd22c9-5d32-4e91-9a46-ab6600b6c1dd [2]https://www.historicenvironment.scot/archives-and-research/publications/publication/?publicationId=0652b7cd-7482-4425-81a9-aad2010ea614

8 Good practice examples: built environment and adaptation to climate change

The following pages provide examples of good practice policies in the strategic area of *built environment and adaptation to climate change*.

8.1 Croatia – Croatian Building Act

Policy/initiative	Croatian Building Act (Zakon o gradnji)
Location	National level
Start year	2013 (December); most recent version in force since 28 December 2019
Status	Ongoing
Building types	According to Article 2 of the Building Act, its provisions apply to all construction works in the territory of the Republic of Croatia (excluding mining structures and facilities, military construction works and other construction works regulated under special regulations/a special act) [2]. The provisions apply to new construction works and to the reconstruction, removal and maintenance of existing construction works, unless otherwise specified. [2] Article 3, No. 27. of the Building Act defines a building as "a closed and/or covered construction work which is intended for the residence of human beings or for the accommodation of animals, plants and things. […]". Article 3, No. 28. defines a public building as "a building or a part thereof used by public authorities for performing their activities, a building or a part thereof used for residential purposes and a non-residential building or part thereof in which a number of people are present or a larger number of people are provided a service." [2] Therefore, the Building Act covers residential (single-family buildings, multi-family buildings, etc.), non-residential and public buildings alike.
Type of policy	Reguation (Act)
Short description	Article 15 of the Building Act, in force since 28 December 2019, stipulates that "buildings must be designed, constructed and removed in such a way that the use of natural resources is sustainable, and in particular must guarantee the following: 1) reuse or recyclability of the building, its materials and parts after removal 2) durability of the building 3) use of environmentally friendly raw materials and secondary materials in buildings." [1] Such a legal stipulation to design buildings for reuse and recyclability and for durability sets an effective framework to foster circular design and buildings, and is seldom found across the countries analysed.
Primary energy savings	No information available
CO_2 emission savings	No information available
Costs	No information available
Increased renovation rate and depth	No information available

Ease of implementation	The Building Act seems to be transferable across countries and climate zones, because stipulations can be adapted to the specific climatic, socio-demographic and socio-cultural context of different countries. As the Building Act encompasses a wide diversity of building types, transferability appears high in this regard, too. The Building Act is administered on the national level by the Ministry of Construction and Physical Planning. It is responsible for supervision of the implementation of the Act and regulations adopted on the basis of it, and of the legality of activities and actions of the administrative bodies of local self-government or regional units and legal persons (see Article 156). Building permits and use permits are issued by the Ministry and the administrative body of a major city, city of Zagreb or a county competent for carrying out administrative construction activities (see Article 99). In case of misconduct and misdemeanour of actors along the building value chain, e.g. if administrative bodies or legal persons fail to comply with the stipulations of the Building Act, fines will be imposed and in case of grave misconduct criminal charges could be instigated.
Matching EU policy framework	• The Building Act transposes Directive 2010/31/EU on the energy performance of buildings into the legislation of the Republic of Croatia. In addition, the Building Act fits the foci and objectives of recent EU policies addressing the Circular Economy in the buildings sector, in particular the: • European Green Deal (e.g. chapter 2.1.4 Building and renovating in an energy and resource efficient way) from December 2019; • New Circular Economy Action Plan 'For a cleaner and more competitive Europe' from March 2020 (e.g. chapter 3.6. Construction and buildings) • Circular Economy Principles for Building Design from 2019 (e.g. fostering the use of recycled materials).
Strategic area(s) addressed	The Building Act stipulates as essential requirements for construction works (see Article 8): "1. mechanical resistance and stability; 2. fire safety; 3. hygiene, health and the environment; 4. safety and accessibility in use; 5. noise protection; 6. energy economy and heat retention; 7. sustainable use of natural resources." [2] Therefore, the Building Act in particular addresses the objective of the strategic area "increased sustainable infrastructure in the built environment (including enhanced resilience of buildings)" by fostering both circular building design and the use of recycled materials in buildings. There is no information on the extent to which the objectives have been tackled.
Lessons learned	• Success factors: – Building Act covers environmental and health-related issues (see Article 8), which renders its stipulation relevant for several objectives and thus increases acceptance among citizens • Challenges for implementation

	– Insufficient communication and coordination between local and central authorities on building enforcement issues [3]
Synergies	According to the essential requirements for construction works laid down in Article 8, the stipulations of the Building Act could also have a positive effect on the strategic areas: • "Improve health and wellbeing", because construction works must be designed and built in such a way that • "[over its entire life-cycle] it will not be a threat to the hygiene or health and safety of workers, occupants or neighbours […]" (see Article 11) • "it does not present unacceptable risks of accidents or damage in service or in operation such as slipping, falling, collision, burns, electrocution, injury from explosion, and burglaries. In particular, construction works must be designed and built taking into consideration accessibility and use for disabled persons." (see Article 12) • "noise perceived by the occupants or people nearby is kept to a level that will not threaten their health and will allow them to sleep, rest and work in satisfactory conditions" (see Article 13) [2] • "Energy poverty", because "construction works and their heating, cooling, lighting and ventilation installations must be designed and built in such a way that the amount of energy they require in use shall be low, when account is taken of the occupants and of the climatic conditions of the location of the construction work. Construction works must also be energy-efficient, using as little energy as possible during their construction and dismantling." (see Article 14) [2]
Bibliography	[1] Zakon HR (2020). *Zakon o gradnji, pročišćeni tekst zakona, NN 153/13, 20/17, 39/19, 125/19, na snazi od 28.12.2019.* https://www.zakon.hr/z/690/Zakon-o-gradnji [2] Croatian Parliament (2013). *Decision promulgating the Building Act*. Provisional Translation. Zagreb. https://mgipu.gov.hr/UserDocsImages/dokumenti/Propisi/Building_Act.pdf [3] Jovanović T., Aristovnik A. and Rogić Lugarić T. (2016). A comparative analysis of building permits procedures in Slovenia and Croatia: development of a simplification model. *Theoretical and Empirical Researches in Urban Management* 11(2).

8.2 Denmark – Circle House Lab

Policy/initiative	Circle House Lab Denmark (native language and English)
Location	Municipal level, but bringing together and being accessible to actors from across Denmark International outreach via annual Circle House Summit
Start year	2018, with actual Circle House building expected to be completed in 2020.
Status	Ongoing
Building types	Residential (single-family buildings, multi-family buildings, etc.), non-residential public buildings
Type of policy	Exchange platform for capacity building and scaling-up of circular building
Short description	The Circle House Lab is a multi-stakeholder exchange platform and laboratory for experimenting with circular building solutions across the industry. It is located in the Circle House (60 social housing units in Lisbjerg outside Aarhus), designed to be the world's first residential building constructed according to circular principles (90% of the project's materials must be able to be reused without loss of value-use [1]). With the Circle House, BLOXHUB (as physical and digital host of the Circle House), Realdania and the Danish Environmental Protection Agency's Development and Demonstration Pool (MUDP) aim to offer a circular example built on market conditions. [2] The Circle House Lab aims to accelerate the transition to a circular economy in the Danish building industry by: • Developing solutions and standards such as digital building logbooks on selective demolition, design for disassembly and circular construction (adapt the building stock to demographic fluctuations) • Providing advice to renew traditional business models and to ensure that the legislation supports recycling and circular construction • Providing a platform for exchange between different actors • Serving as a scalable demonstration project to provide new knowledge to the construction industry on the experience of circular building and to encourage scaling-up. Tackling the key challenges requires multi-stakeholder dialogue along the building value chain. The Circle House Lab provides a promising platform for such dialogue and for joint progress. [3]
Primary energy savings	No information available Lab.
CO_2 emission savings	The demonstrator building Circle House achieves CO_2 emission saving sthrough various circular material uses: • Using reusable carpet tiles as part of the concept of the Circular House helps save 66% of CO_2 emissions – based on the assumption that 100% of the carpeting materials are reusable. • Using reusable plasterboard for walls saves 45% CO_2 compared with a conventional plasterboard wall. • Using easily demountable and recyclable acoustic ceilings reduces carbon emissions by 65% compared with conventional acoustic ceilings – based on the assumption that 90% of the panels can be reused directly.

	• Using façade tiling systems with clay shingles, where tiles can easily be disassembled and reused, provides a carbon saving of 45% – based on the assumption that 90% of the clay shingles can be reused directly. • Using precast concrete structures that are easy to disassemble and reuse delivers a saving of 45% CO_2 as compared with conventional precast structures, based on the assumption that 90% of the precast concrete structure can be reused directly [1].
Costs	
Increased renovation rate and depth	No information available
Ease of implementation	
Matching EU policy framework	
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	
Lessons learned	
Synergies	The Circle House Lab could have synergies with the strategic area “Improve health and wellbeing”, because circular construction allows taking into account health and wellbeing aspects of building materials and building design (e.g. adaptive design for family vs. singles vs. elderly).
Bibliography	[1] GXN and Responsible Assets (2018). Circle House — Denmark’s first circular housing Project. KLS PurePrint. https://gxn.3xn.com/wp-content/uploads/sites/4/2019/02/CircleHouse_ENG_2018.pdf [2] BLOXHUB (2020). *Who is behind the Cirlce House Lab?* https://bloxhub.org/circle-house-lab-activities-in-circle-house-lab [3] BLOXHUB (2020). *Circle House Lab*. https://bloxhub.org/circlehouselab

8.3 The Netherlands – Transition Agenda Circular Construction Economy

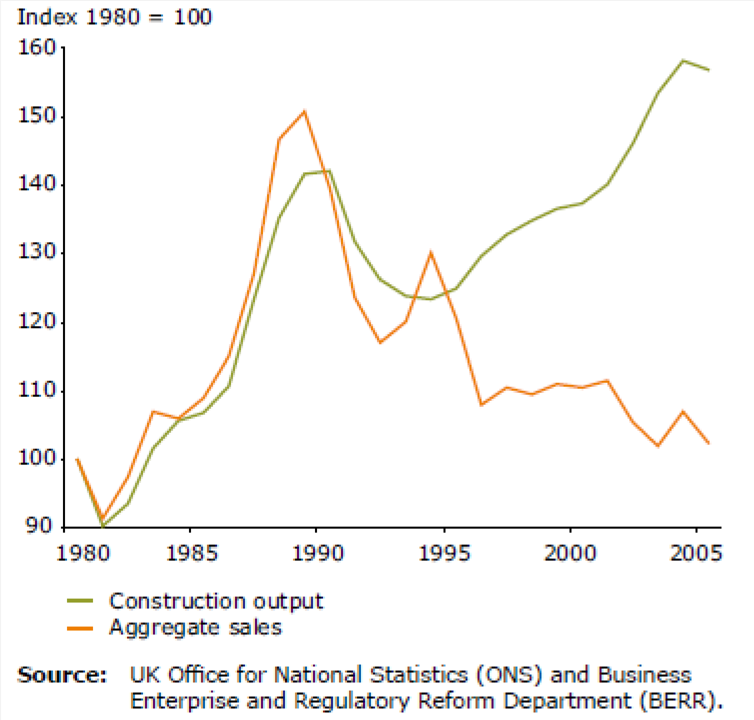
Policy/initiative	Dutch Transition Agenda Circular Construction Economy (Transitie-Agenda Circulaire Bouweconomie)
Location	National
Start year	2018
Status	Ongoing
Building types	Residential and non-residential buildings
Type of policy	Programme and stakeholder agenda for capacity building, experimenting, cooperating and sharing knowledge through stakeholder exchange along a joint transition agenda
Short description	The transition agenda describes the strategy for achieving a circular construction economy in 2050 in the Netherlands, and constain specific recommendations for the period 2018-2021. It was drawn up by a transition team of experts from science, government and market parties. The agenda's recommendations encompass: • A decision on the use of a materials passport by 2020 • That all government procurement must be circular by 2030 • That circular construction be an integral part of education by 2021 • Introducing circularity in building codes. Integrating circular design into building codes and education of building professionals promises long-term effects towards making circular buildings the new default.
Primary energy savings	No information available
CO_2 emission savings	No current information, but the transition team highlights the potential contribution of circular building to the reduction of CO_2 in the extraction, manufacture and transport of materials in the construction industry. Aiming to halve CO_2 emissions in the construction industry by 2030 and to completely eliminate emissions by 2050 over the entire lifecycle from production and manufacturing to the use phase and transport, this will result in "*a reduction of about 107 megatons of CO_2-eq (per annum for both civil engineering and utility construction and ground, water and road construction). In 2030, the total emission will be halved, resulting in a reduction of 53 megatons CO_2-eq.*" [1, p. 7/8]
Costs	Not available
Increased renovation rate and depth	Not available
Ease of implementation	Not available
Matching EU policy framework	Not available
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built	Not available

environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	
Lessons learned	
Synergies	The Transition Agenda Circular Construction Economy could have synergies with the strategic area 'increase smart readiness of buildings", because smart buildings constitute a component of strategic research foreseen under the transition agenda.
Bibliography	[1] Transition Agenda Circulair Economy (2018). Circular Construction Economy. https://hollandcircularhotspot.nl/wp-content/uploads/2019/09/Circular-Construction-Economy.pdf

8.4 United Kingdom – Aggregates Levy

Policy/initiative	Aggregates Levy
Location	National level (UK)
Start year	2002
Status	Ongoing
Building types	The Aggregates Levy is not specific to building types (e.g., residential, non-residential, public) because it is charged on any aggregate used for construction purposes (e.g., as part of a building). Use for construction purposes is assumed when the aggregate: (1) serves "as material or support in the construction or improvement of any structure (2) is mixed with anything as part of a process of producing mortar, concrete, tarmacadam, coated roadstone or any similar construction material" [1] According to the UK government, structures include "buildings, bridges, roads, paths, the way on which any railway is laid (or is to be laid), and embankments" [1]. Building types are not further specified.
Type of policy	Tax (economic instrument)
Short description	The Aggregates Levy is a tax on the commercial exploitation of sand, gravel and rock, which has been dug from the ground, dredged from the sea in UK waters or imported (exports are excluded). [1] It is levied per tonne of sand, gravel and rock extracted, but does not apply to recycled aggregates [2]. Anyone responsible for commercially exploiting aggregates in the UK, including quarry operators, is obliged to register for and pay the Aggregates Levy [1]. The Aggregates Levy pursues two objectives: 1) First and foremost to tackle environmental and health impacts and costs associated with extraction activities (quarrying operations), such as noise, dust, loss of amenity and damages to biodiversity and ecosystems. 2) Secondly, to reduce the demand for virgin aggregates and encourage the use of alternative materials, e.g., recycled construction materials. [2] As aggregates are a key building material, increasing their prices by taxing them provides incentives for (instead or in addition) using secondary materials from domestic sources for construction projects.
Primary energy savings	There are no figures on primary energy savings related to the introduction of the Aggregates Levy. In general, trends in the UK show an increase in construction output between 1980 and 2005 and a decline in aggregates output between the late 1980s and 2005 (see Figure 1 below). While a general downturn in road-building since 1990 was a driving force behind this decline, the Aggregates Levy – and to a much greater extent the introduction of the landfill tax in 1996 – contributed to a more efficient use of aggregates in construction works [3].

Figure 1: Trends in construction output and primary aggregate sales in the UK



Source: [3], p. 27

Together with the landfill tax, the Aggregates Levy incentivised modest increases in the demand for recycled aggregates, rising from around 2 million tonnes per annum before the introduction of the levy to 3 million tonnes per annum after its introduction [3]. In 2005, recycled aggregates accounted for almost 25% of the UK aggregates market [3].

CO_2 emission savings

No information available.

Costs

The levy charges £2 per tonne of sand, gravel or rock. The levy is a specific one stage tax, which is non-deductible and therefore cannot be reclaimed as input tax (unlike VAT) [1].

In 2008/2009 state revenues from the Aggregates Levy amounted to €380 million [4]. All state revenues from the Aggregates Levy are earmarked and transferred back to businesses. Transfer mechanisms encompass (i) a 0.1% reduction in employer contributions to national insurance and (ii) the so-called Aggregates Levy Sustainability Fund (ALSF), which promotes greater use of recycled aggregates and provides funds to support better environmental management at aggregate sites [2, 3].

Annual administrative costs related to the Aggregates Levy are estimated to stand around €1.1 million, while compliance costs for industry are estimated to be less than 0.6 cents per tonne extracted [4].

Increased renovation rate and depth

No information available.

Ease of implementation

The Aggregates Levy seems transferable to other countries, as examples from Denmark and Sweden show, where similar taxation has been put in place [2, 3]. Aggregates covers sand, gravel and rock, which are relevant building materials in most countries – it does not cover biotic building materials (e.g. wood) nor steel.

	The policy is administered on the national level by Her Majesty's Revenue and Customs (HMRC), with all actors commercially exploiting sand, gravel or rock having to register and pay the levy to HRMC. In case of failure to register and pay, different levels of fines can be imposed (e.g. when not notifying for registration, fines are £250 or 5% of the levy involved, whichever is the greater) or even criminal sanctions in case of evading the levy. The landfill tax, introduced in 1996, is a key enabler because it already provided an incentive for greater reuse of construction and demolition waste, e.g. by using more recycled aggregates. As the Aggregates Levy exempts recycled aggregates, there is a double incentive for greater use of recycled aggregates. It was partly this policy mix of landfill tax and Aggregates Levy which proved to be effective. UK experience with the Aggregates Levy shows that tax rates need to consider potential distortions across country borders. In the UK case, the proximity between Northern Ireland (part of the UK, Aggregates Levy in place) and Ireland (no aggregates taxation) yielded large tax differentials and triggered illegal trade across country borders from Ireland to the UK [3].
Matching EU policy framework	There is no clearly linked EU policy framework. However, the Aggregates Levy does fit the foci and objectives of recent EU policies addressing the circular economy in the buildings sector, in particular the: • European Green Deal (e.g. chapter 2.1.4 Building and renovating in an energy and resource efficient way) from December 2019 • New Circular Economy Action Plan 'For a cleaner and more competitive Europe' from March 2020 (e.g. chapter 3.6. Construction and buildings) • Circular Economy Principles for Building Design from 2019 (e.g. fostering the use of recycled materials).
Strategic area(s) addressed	"Increased sustainable infrastructure in built environment (including enhanced resilience of buildings)" – fostering the use of recycled materials in buildings. Together with the landfill tax, the Aggregates Levy incentivised modest increases in the demand for recycled aggregates, raising from around 2 million tonnes per annum before the introduction of the levy to 3 million tonnes per annum after its introduction [3].
Lessons learned	• Success factors: – Combination with the landfill tax as part of a policy mix seems effective, measured by increase in demand for recycled aggregates – Recycling of tax revenues back to businesses and to support them in increasing use of recycled aggregates increases acceptance of Aggregates Levy – Due to mostly national use of aggregates the Aggregates Levy has no or only negligible competitive impacts [2, 3]. • Challenges of implementation: – Tax rate differentials between neighbouring countries need border tax adjustments in order to discourage illegal trade
Synergies	Although there is hardly any effect on noise and dust emission reduction through the Aggregates Levy (and use of its state revenues through the ALSF) (see [3]), effects on the strategic area 'improve health and wellbeing' are conceivable.

Bibliography	[1] UK government (2017, February). *Excise Notice AGL1: Aggregates Levy*. https://www.gov.uk/government/publications/excise-notice-agl1-aggregates-levy/excise-notice-agl1-aggregates-levy [2] Söderholm, P. (2011). Taxing virgin natural resources: Lessons from aggregates taxation in Europe. *Resources, Conservation and Recycling* 55, 911– 922 [3] EEA (2008). Effectiveness of environmental taxes and charges for managing sand, gravel and rock extraction in selected EU countries. EEA Report No 2/2008, Copenhagen [4] Ecorys et al. (2011). The role of market-based instruments in achieving a resource efficient economy. Rotterdam.

8.5 Germany – Circular Economy Act

Policy/initiative	Germany Circular Economy Act (Kreislaufwirtschaftsgesetz KrWG)
Location	National
Start year	2012
Status	Ongoing
Building types	No building types specified
Type of policy	Regulation (Act)
Short description	Section 45 "Obligations of the public sector" of the Circular Economy Act obliges, among others, authorities and agencies to contribute, through their conduct, including procurement, to promote the circular economy in order to conserve natural resources and to ensure the protection of human health and the environment in the generation and management of waste. For this purpose, they shall examine *"[…] in construction projects and other contracts […] to what extent* 1. products can be used, a) that are particularly durable, are easy to repair, reusable or recoverable, b) that result in less waste or less-polluting waste in comparison to other products, or c) that are made from waste in the process of preparation for re-use or recycling, and 2. the waste occurring after the use of the products can be recovered, particular consideration being given to the priority of preparing for re-use and of recycling." [1] Green public procurement is a key instrument to push demand for secondary materials in buildings and to build up secondary markets. Stipulating that public procurers examine purchasing of products made from secondary materials fosters circular procurement. Furthermore, Section 14 sets the following target in relation to non-hazardous construction and demolition waste (CDW): "The preparation for re-use, recycling and the other material recovery of non-hazardous construction and demolition waste […] should be a minimum of 70 % by weight at the latest from 1 January 2020 onwards. Other material recovery in accordance with the first sentence shall include backfilling operations using waste to substitute other materials. […]" [1] The Circular Economy Act prioritises material use of CDW and uses, inter alia, green public procurement to foster the demand for secondary building materials obtained from CDW.
Primary energy savings	No information available
CO_2 emission savings	No information available
Increased renovation rate and depth	No information available
Ease of implementation	
Matching EU policy framework	
Address	

• Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	
Lessons learned	
Synergies	Fostering green public procurement for secondary building materials via the Circular Economy Act could have synergies with the strategic area "Secure fair transition", when usually cheaper costs for buying and transporting secondary building materials could result in lower overall costs for construction and might increase the fairness of the transition for public bodies.
Bibliography	[1] Deutscher Bundestag (2012). Act Reorganising the Law on Closed Cycle Management and Waste (Gesetz zur Neuordnung des Kreislaufwirtschafts- und Abfallrechts) *) of February 24th 2012. https://www.bmu.de/fileadmin/Daten_BMU/Download_PDF/Abfallwirtschaft/kreislaufwirtschaftsgesetz_en_bf.pdf

8.6 Spain – Demolition Waste National Plan for 2016-2022

Policy/initiative	Spanish Demolition Waste National Plan for the period 2016 – 2022 (Plan Estatal Marco de Gestión de Residuos 'PEMAR' 2016-2022)
Location	National
Start year	2016
Status	Ongoing
Building types	Not specified
Type of policy	National plan
Short description	The national plan aims to reduce resource use, increase the recycling rate and improve resource efficiency. The plan has a specific chapter targeting construction waste and demolition in order to promote actions for reutilisation and recycling of construction material to ensure that Spain complies with EU legal objectives. The plan pursues a diversity of objectives, suggesting an effective policy mix of, inter alia: • Research, development and innovation regarding the durability and recycling possibility of the materials, which will play an important role in achieving EU recycling targets • Increasing taxes (economic disincentives) • Encouraging the use of sustainable products.
Primary energy savings	No information available
CO_2 emission savings	No information available
Costs	No information available
Increased renovation rate and depth	No information available
Ease of implementation	
Matching EU policy framework	
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context	

(including access to sustainable mobility)	
Lessons learned	
Synergies	The policy appears not explicitly or directly linked to other strategic areas.
Bibliography	[1] BIO by Deloitte, BRE, FCT, ICEDD, RPS and VTT (2014). *Construction and Demolition Waste management in Spain.* https://ec.europa.eu/environment/waste/studies/deliverables/CDW_Spain_Factsheet_Final.pdf *[2]* Ministeriode Agricultura, Alimentación y Medio Ambiente (2015). *Plan Estatal Marco de Gestión de Residuos (Pemar) 2016-2022.* https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/planes-y-estrategias/pemaraprobado6noviembrecondae_tcm30-170428.pdf

8.7 *Ireland – Building Regulation Part L (technical guidance)*

Policy/initiative	Building Regulation Part L - technical guidance document (Ireland)
Location	National
Start year	2019
Status	Ongoing
Building types	Residential (dwellings)
Type of policy	Technical guidance
Short description	Avoiding overheating due to solar gain is a key design requirement to minimise the use of mechanical cooling and reduce energy consumption by cooling systems. Good low-energy design will seek to minimise the effect of excessive solar gains in summer by appropriate orientation, massing and selection of the building façade. However, additional measures may still be required to provide solar shading to the building to reduce solar gains and the associated risk of overheating. As one of the aims, the document gives guidance on "Limiting Heat Gains: ensuring that the building is appropriately designed to limit heat gains through the fabric."
Primary Energy savings	No information. Supports passive ventilation and low energy measures.
CO_2 emission savings	No information. Supports passive ventilation and low energy measures.
Costs	No information
Increased renovation rate and depth	No information
Ease of implementation	• It is transferable to other countries with problems of overheating, which is relevant for a larger number of urban areas in the EU. • Policy is designed as national guidance. • It is a technical guidance to support implementation of the building regulation. • It refers to the "Technical Guidance: Design for improved solar shading control, CIBSE TM37" which includes more details.
Matching EU policy framework	• Technical guidance of COM
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings	• Improve health and wellbeing: decreasing heat within dewllings leads to a higher wellbeing and can avoid health issues due to heat stress.

• Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	
Lessons learned	• The document relates to a guidance document with more details from the UK, which is already in use since 2006 and can be seen as a well-established document. • No enforcement possibilities because of character of technical guidance – the aim within the building regulation is stated in broad sense.
Synergies	Links to the strategic area of "health and wellbeing", which has the aim to achieve a healthy indoor environment.
Bibliography	[1] Government of Ireland (2019): Building Regulation - Technical Guidance Part L 2019. Prepared by the Department of Housing, Planning and Local Government, https://www.housing.gov.ie/sites/default/files/publications/files/tgd_l_dwellings_2019.pdf [2] CIBSE (2006): Design for improved solar shading control. TM37: 2006. The Chartered Institution of Building Services Engineers.

8.8 Gräfelingen (Germany) – Support programme for rainwater utilisation

Policy/initiative	Gräfelfingen support programme for rainwater utilisation (Municipality of Gräfelfing) (Gräfelfinger Förderprogramm zur Regenwassernutzung)
Location	Municipal level
Start year	2020
Status	
Building types	Private owners and tenants - residential, non-residential
Type of policy	Grant
Short description	The municipality of Gräfelfing is promoting the construction of cisterns to collect and use rainwater for garden irrigation and/or service use. The amount of funding depends on the size of the cistern. Eligible to apply are building owners (private owners, owners' associations) and tenants, provided that the landlord's declaration of consent is available. The municipality of Gräfelfing supports the construction of rainwater cisterns, devices for the supply of rainwater and the necessary installations for the use of rainwater.
Primary energy savings	No information. Not objective of measure.
CO_2 emission savings	No information. Not objective of measure.
Increased renovation rate and depth	No information.
Synergies	Not applicable
Bibliography	Gräfeling: Gräfelfinger Förderprogramm zur Regenwassernutzung 2020. https://www.graefelfing.de/fileadmin/user_upload/Energie_und_Umwelt/F%C3%B6rderprogramme/Foerderprogramm_Regenwassernutzung_2020_neu_02.pdf

8.9 Norway – Technical building regulations

Policy/initiative	Norway technical builiding regulations (Forskrift om tekniske krav til byggverk (Byggteknisk forskrift -TEK17)
Location	National
Start year	2017
Status	Ongoing
Building types	Residential, non-residential, public buildings (construction work)
Type of policy	Technical regulation
Short description	The regulation is intended to ensure that projects are planned, designed and executed on the basis of good visual aesthetics, universal design, and in a manner that ensures that the project complies with the technical standards for safety, the environment, health and energy. Construction works are to be sited, designed and constructed to ensure satisfactory protection against damage or significant nuisance from acts of nature. The building code prescribes minimum measures that need to be taken to protect against natural stresses (e.g. flooding and landslides). The technical regulation also includes a section on thermal comfort which describes the recommended temperatures, passive measures and opening of windows and doors.
Primary Energy savings	No information. Not main objective of measure.
CO_2 emission savings	No information. Not main objective of measure.
Increased renovation rate and depth	No information
Synergies	The aspect on thermal comfort has links to the strategic area "health and wellbeing", which aims to achieve a healthy indoor environment.
Bibliography	Direktoratet for Byggkvalitet (2017): Byggteknisk forskrift (TEK17) med veiledning. https://dibk.no/byggereglene/byggteknisk-forskrift-tek17/13/vi/13-11 Norwegian Building Authority (2017): Regulations on technical requirements for construction works. An unofficial English translation of the regulation "Forskrift om tekniske krav til byggverk (Byggteknisk forskrift - TEK17)" for information purposes.

8.10 Bavaria (Germany) – Support for rainwater use

Policy/initiative	Information on rainwater uses in homes related to the financial support, advantages, costs and benefits, basis for calculation. (Homeowners' Association Bavaria e.V.) (Regenwassernutzung im Haus Niederschlagswasser: Vom lästigen Abwasser zum geschätzten Rohstoff)
Location	Regional level
Start year	No date
Status	Ongoing
Building types	Residential
Type of policy	Information portal
Short description	Information on rainwater uses in homes related to the financial support, advantages, costs and benefits, basis for calculation. It describes the reasons for rainwater storage in homes; details preconditions, advantages, possible water use and possibilities for financial support (including links to provider of support); gives examples for calculation of cistern volume for different building types.
Primary Energy savings	No information. Not objective of measure.
CO_2 emission savings	No information. Not objective of measure.
Increased renovation rate and depth	No information.
Synergies	No links can be seen
Bibliography	Eigenheimerverband Bayern e.V.: Regenwassernutzung im Haus Niederschlagswasser: Vom lästigen Abwasser zum geschätzten Rohstoff. https://www.eigenheimerverband.de/tipps-fuer-recht-garten-haus/haus-wohnung/themenarchiv/regenwassernutzung

8.11 Denmark – Climate Atlas

Policy/initiative	Climate Atlas (Klimaatlas), Denmark
Location	National level
Start year	No date
Status	Ongoing
Building types	Residential, non-residential, public
Type of policy	Information portal
Short description	The tool is a nationwide Climate Atlas based on own data and data from the IPCC. Data is free and available on DMI's website, both at national and municipality levels – and down to a 1 km grid scale. The Danish Climate Atlas provides data on municipality, drainage basin and coastal stretch levels showing future changes in temperature, precipitation, extreme precipitation, relative sea level and storm surge heights. It thereby gives an indication of areas with a particular future risk of being impacted by extremes. The tool provides the fundamental climate data so municipalities can take the necessary precautions and guard citizens, infrastructure and buildings against the expected extreme weather in the future. In Denmark, the municipalities are responsible for climate adaptation, for example, building dykes or securing exposed areas from cloudbursts. The Danish Climate Atlas therefore has the municipalities and their climate adaptation as its primary focus, but it is also relevant for the regions, utility companies, infrastructure, agriculture, emergency management, insurance, consultants and many other sectors. The Climate Atlas is developed in a valuable collaboration with the municipalities and other relevant stakeholders working on climate adaptation.
Primary Energy savings	No information. Not objective of measure.
CO_2 emission savings	No information. Not objective of measure.
Increased renovation rate and depth	No information
Synergies	No links can be seen
Bibliography	ClimateChangeAdaptation: Climate Atlas. https://en.klimatilpasning.dk/tools/climate-atlas DMI: Klimaatlas. https://www.dmi.dk/klimaatlas

8.12 USA – Watersense programme

Policy/initiative	WaterSense programme, USA
Location	National level
Start year	2012
Status	Ongoing
Building types	Residential (single-family, multi-family)
Type of policy	Voluntary partnership programme/label
Short description	WaterSense is a voluntary partnership sponsored by the U.S. Environmental Protection Agency (EPA), which labels water-efficient products, new homes and programmes and provides resources on how to save water. For WaterSense labelled homes, the following issues are included: • Indoor criteria: leaks, service pressure, hot water delivery, plumbing fixtures, dishwashers and clothes washers • Outdoor criteria: landscape design, irrigation system, pools and spas. Several revisions and expansions have come into force since 2012, e.g. having started with single-family homes, the programme now includes multi-family homes. The programme offers a number of additional tools, e.g. a Water Budget Tool, information on water-smart landscapes, and an information page for kids.
Primary Energy savings	No information. Water efficiency is main objective of programme, but criteria also include energy efficiency of dishwashers and clothes washers.
CO_2 emission savings	No information. Water efficiency is main objective of programme, but criteria also include energy efficiency of dishwashers and clothes washers.
Increased renovation rate and depth	No information.
Synergies	No links can be seen
Bibliography	EPA: WaterSense - Homes. https://www.epa.gov/watersense/homes

8.13 Tyrol (Austria) – Climate-friendly construction

Policy/initiative	Measures catalogue: Climate-friendly construction, Tyrol
Location	Regional level
Start year	2012
Status	Ongoing
Building types	Residential, non-residential, public buildings
Type of policy	Information material
Short description	The measures catalogue includes synergy measures between climate protection, climate change adaptation and living comfort (heat and cold insulation and ventilation concepts), as well as measures to adapt to a changed natural hazard potential (flood protection) or include adequate dimensioning of drainage infrastructures. The catalogue includes measures for energy-efficient buildings and restoration of buildings. It includes information on total costs for different house types (e.g. Klima-Haus, 1 litre house, etc.) and amortisation of these investment costs. It includes also soft measures such as financial support programmes, advice and knowledge, and covers different labels and good practice examples.
Primary energy savings	No information
CO_2 emission savings	No information
Increased renovation rate and depth	No information
Synergies	Includes links to strategic area “health and wellbeing”
Bibliography	CIPRA (2009). Bauen und Sanieren im Klimawandel. Ein Hintergrundbericht der CIPRA. COMPACT; 02/2009.

8.14 City of Portland (USA) – Green Building Policy

<table>
<tr><td>Policy/initiative</td><td>City of Portland Green Building Policy (City of Portland)</td></tr>
<tr><td>Location</td><td>Municipal level, Portland</td></tr>
<tr><td>Start year</td><td>Implemented in 2001 and updated in 2015 with Resolution 37122</td></tr>
<tr><td>Status</td><td>Ongoing</td></tr>
<tr><td>Building types</td><td>Construction and rehabilitation projects of affordable multifamily residential and mixed-use buildings that have a minimum of 20 units receive at least 10% of total project funding from the Portland Housing Bureau</td></tr>
<tr><td>Type of policy</td><td>Policy</td></tr>
<tr><td>Short description</td><td>The policy obligates new, occupied city-owned buildings to achieve Leadership in Energy and Environmental Design (LEED) Building Design and Construction (BD+C) at the Gold level. They should also include eco roofs and storm water management strategies and related watershed enhancement strategies in their design, and provide adequate bicycle parking opportunities (equal to 25% of the target in the city's climate action plan). In addition, all city-owned, occupied, existing buildings must achieve LEED Silver certification and all new commercial or mixed-use buildings over 10,000 square feet that receive financial assistance from the Portland Development Commission of US$300,000 or more and that also equals 10% of the total project cost must achieve LEED Silver certification. Since 2007, Portland has the highest number of LEED-certified buildings in the US.</td></tr>
<tr><td>Primary energy savings</td><td>The goal is to reach net zero energy consumption in affordable housing projects by 2050
<table>
<tr><td>Year</td><td>2025</td><td>2030</td><td>2035</td><td>2040</td><td>2045</td><td>2050</td></tr>
<tr><td>Net EUI</td><td>23</td><td>18</td><td>12</td><td>8</td><td>4</td><td>0</td></tr>
</table>
As part of the certification requirement for new construction, 28% net EUI of projects under the policy must be met in 2020. The projects must include charging stations at 4% of the parking spaces on site or be electric vehicle-ready at 10% of parking spaces.</td></tr>
<tr><td>CO_2 emission savings[5]</td><td>Building construction and operations account for 35% of US CO_2 emissions. Green buildings increase energy efficiency, reduce, reuse, and recycle materials, and promote transit-oriented development, which helps meet CO_2 emissions-reduction goals.</td></tr>
<tr><td>Costs</td><td>The construction cost data shows a moderate difference (4.6%) in average cost between the green-rated buildings and standard buildings. While green buildings mostly have a similar or lower cost than conventional buildings, upfront investments in green features may be higher. However, savings in operations and maintenance expenses make up for construction costs quickly, with initial investments paid back in one to ten years.</td></tr>
<tr><td>Increased renovation rate and depth</td><td>• 15% energy savings beyond the applicable Oregon Energy Efficiency Specialty Code</td></tr>
<tr><td>Ease of implementation</td><td>• Projects for which the policy applies are awarded a letter from the Portland Housing Bureau stating the requirements. However, the policy explicitly acknowledges the need for flexibility, workability and cost reduction.</td></tr>
</table>

	• The policy is administered at the municipal level and should easily be transferable to other cities • Compliance: Upon receipt of the PHB award letter, the developer submits an application for third-party certification. As applicable, the developer submits a LEED Checklist or Earth Advantage Points Worksheet each time they are updated to PHB indicating: a. Progress towards meeting the requirements of this Policy b. Likelihood that the respective certification requirements will be met or exceeded c. c. Any issues or circumstances that may prevent the developer from meeting this Policy or certification requirements.
Matching EU policy framework	• This example does not apply under the EU framework
Address • Energy poverty • Improve health and wellbeing • Increased sustainable infra-structure in built environment (including enhanced resilience of building) • Increase smart readiness of buildings • Secure fair transition • Upgrade of urban context (including access to sustainable mobility)	• The policy aims to yield long-term savings through efficient management of energy, water, waste and stormwater, as well as improving the health, comfort and productivity of building occupants. • In the years since implementation, Portland has constructed or improved 11 buildings to meet LEED standards.
Lessons learned	The state of Oregon founded the Oregon Built Environment and Sustainable Technologies Research Centre in 2007 as it recognised the potential economic opportunities linked to green buildings. In addition, the Oregon Ecnomic and Community Development Department has been in an exchange with the green building industry to identify how best to support development of an economically competitive cluster. This is an example where municipal policy successes informed the state level.
Synergies	The policy is linked to the climate action plan of Portland and Multnomah County. The city of Portland's 2009 climate action plan mandated that buildings within the city get their energy from renewable sources; 15% of which is to be from on-site renewable energy generation
Bibliography	[1] Allen J.H. and T. Potiowsky (2008). *Portland's Green Building Cluster – Economic Trends and Impacts.* DOI: 10.1177/0891242408325701 [2] City of Portland (2015). ENB-9.01 *Green Building Policy* https://www.portlandoregon.gov/citycode/article/54355

8.15 Germany – Green in the City

Policy/initiative	Bundesweite Initiative „Grün in der Stadt" (nationwide initiative - Green in the City)
Location	National level, put into practice on the municipal level
Start year	2015
Status	Ongoing
Building types	Various
Type of policy	Initiative
Short description	The "Green in the City" initiative and the new urban development support programme "Zukunft Stadtgrün" (Future City Green) put a spotlight on the importance of urban green infrastructure in Germany. For the first time in Germany, the intiative opens up the possibility of an area-wide promotion of green roofs and facades within the framework of urban development funding. The programme of measures does not directly set out funding for green roofs and facades; however, they are indirectly eligble for public funding. As the administrative agreements between the federal government and the federal states are of a very general nature, the federal states have room for interpretation to include their own political objectives.
Primary energy savings	Doesn't apply to green roofs, unless combined with solar energy on roofs. In Germany, photovoltaic plants made up 6.5% of energy in 2015. Three-quarters of photovoltaic power in Germany stems from modules installed on roofs.
CO_2 emission savings	Assuming that only 10% of the annually sealed area can be renaturalised by extensive green roofs, which corresponds to an area of about 1,600 ha in Germany, it is possible that up to 19,000 tonnes of CO_2 could be permanently bound again in the form of carbon by the above-ground vegetation alone.
Increased renovation rate and depth	No information available.
Synergies	Green roofs and facades are usually viewed in combination with other green infrastructure (e.g. parks and urban trees), so a combined concept makes sense. Due to urban green's potential to increase biodiversity and lessen the risks linked to climate change, a combined approach would be useful.
Bibliography	[1] Institut für Agrar- und Stadtökologische Projekte (IASP) an der Humboldt-Universität zu Berlin (2012): *CO2-Bindungsvermögen der für die Bauwerksbegrünung typischen Pflanzen - Bericht*. Berlin. [2] Bundesamt für Naturschutz (2019). Dach-u und Fassadenbegrünung – neue Lebensräume im Siedlungsbereich, BfN Skripten 528, Leipzig.

8.16 The Netherlands – City Deal Climate Adaptation

Policy/initiative	City Deal Klimaatadaptatie (City Deal Climate Adaptation)
Location	National level (Netherlands)
Start year	2016
Status	Ongoing
Building types	
Type of policy	Cooperation agreement
Short description	Cooperation agreement between 17 public partners and 17 (semi)private cooperation partners and the central government to implement pilot projects to develop new forms of governance and financing structures and innovative solutions. Two of four focus areas concentrate on: climate resilient area development (for public and private parties in development, design, renovation and management); development and integration of nature-based solutions and ecosystem services (examine added value and demonstrate feasibility).
Primary energy savings	Information unavailable (in English language)
CO_2 emission savings	Information unavailable (in English language)
Increased renovation rate and depth	Information unavailable (in English language)
Synergies	The lessons learned within the city deal are shared with other parties, such as educational institutes and water management bureaus. Further, the city deal on climate adaptation is part of the "Agenda Stad" (Urban Agenda).
Bibliography	[1] Website: https://www.citydealklimaatadaptatie.nl

Lessons learned to inform integrated approaches for the renovation and modernisation of the built environment

Annex IV: Analysis of the relevance, feasibility and possible scope of mandatory minimum requirements for existing buildings

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Written by:
Buildings Performance Institute Europe ASBL (BPIE)
and CLIMACT SA

January – 2021

Authors

Jonathan Volt (BPIE) & Quentin Jossen (CLIMACT SA)

Contributors

Sibyl Steuwer, Rutger Broer & Mariangiola Fabbri (BPIE)

Louis Louvet, Caroline Sabbe, Pascal Vermeulen & Julien Pestiaux (Climact)

EXECUTIVE SUMMARY

This report presents the outcomes of the analysis of the scope, timeline and phasing of a progressive implementation of mandatory minimum requirements (MMR) for existing buildings in Europe, including the need for accompanying support policies. This report is one outcome of the wider study *Lessons learned to inform integrated approaches for the renovation and modernisation of the built environment.*

The analysis shows that, if designed properly and embedded in a wider supportive policy framework, MMR can overcome many of the barriers the renovation market is facing, including *lack of interest in energy* renovations*, insufficient awareness* of energy and cost-saving potential and the *split-incentives* dilemma.[1] The highlighted MMR models in this report would all have a considerable renovation impact on the European building stock if designed and implemented effectively. This report also shows that MMR is a collective name for a broad number of policies that can be implemented, and combined with other instruments, flexibly.

MMR definition

MMR is a regulation that mandates certain buildings within a defined territory to meet a certain performance standard, by a specified compliance date or according to natural trigger points in the building's lifecycle (e.g. time of sale). The requirement can apply to all buildings or particular building segments. The underlying metrics of the requirement is typically based on energy performance standards (kWh/m²/year) but can also incorporate broader aspects (e.g. climate performance standards (CO_2/m²/year, whole-life carbon and wider environmental, social and governance factors).

The same concept is referred to as *mandatory minimum energy performance standard* (MEPS) in the Renovation Wave, while it is sometimes referred to as *renovation obligation* or just *minimum performance standards.*

This explorative report has been developed to provide the European Commission with knowledge about the concept of MMR, existing experiences and four policy pathways to consider. The analysis and conceptual work are based on a comprehensive literature study, review of existing cases and extensive stakeholder contributions.

Why do we need mandatory minimum requirements for existing buildings?

The decarbonisation of the European building stock needs a considerable boost to become climate-neutral by 2050. Despite this target, the current renovation rate lingers at 1% and the deep renovation rate is only around 0.2%.[2] This is significantly deviating from the path to meet the EU's climate targets, which require a renovation rate of 3%[3], whereof the majority must be deep renovations.[4] In the first step, the European Commission's Renovation Wave strategy aims to at least double annual energy renovation rates in the next ten years. MMR for existing buildings, in combination with other enabling measures and financial support, could make this happen.

[1] One important type of split incentive corresponds to the situation on the rental market where those getting the benefits from the renovation (i.e. the tenant) are not the same people as those making the capital investment (i.e. the landlord or building owner).
[2] Ipsos & Navigant (2019) Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU. European Commission. (Available: Online)
[3] EUCalc (2020) Long-Term Renovation Strategies: How the building sector can contribute to climate neutrality in the EU. European Commission – Horizon 2020 project. (Available: Online)
[4] Deep renovations are renovations that reduce the energy need with, at least, 50-70%.

MMR has already been implemented in various jurisdictions for this purpose, especially across Europe and the United States. For example, the UK, France, the Netherlands, and Belgium (Flanders and Brussels) have implemented, or have far-reaching plans to implement, MMR for existing buildings. The common purposes of these regulations are to phase-out the worst-performing buildings and trigger renovations. The concept of MMR is also gaining ground in the United States, where several cities and municipalities are implementing MMR for specific building segments (see case studies in Appendix 1).

The implementation of MMR to build on energy performance certificates

All EU Member States have implemented and enforced national energy performance certificate (EPC) schemes, making these the most obvious starting point and design choice for MMR5, especially as most building owners know about EPCs and the infrastructure (experts, compliance, databases etc.) is already in place. The UK was first to set a minimum energy efficiency standard based on the EPC rating, followed by France, Belgium and the Netherlands.

The EPC framework is the most obvious reference point for introducing MMR for existing buildings. The purpose of the EPC is to provide information on a building's energy performance status and to offer suggestions for cost-effective improvements, while less suited for considering whole-life carbon aspects. On an aggregate level, they offer information about the building stock and how it can be decarbonised. The comparability of EPCs across the EU (in terms of aspects like calculations, control and data availability) needs further improvement. EPCs already have a link to voluntary carbon metrics, where a change in the main scope would require additional legislative efforts, in addition to the significant reinforcement and harmonisation already planned in the Renovation Wave strategy.

EPC schemes need to significantly improve in terms of quality and coverage to be able to effectively facilitate an MMR built around them. The remaining issues include:

- The availability of registered EPCs per capita is still too low for the instrument to be used as the universal assessment criteria of the MMR. Only the UK, Ireland, Portugal, Denmark and Belgium have more than 1 EPC registered per 10 inhabitants[6]. Even in England and Wales, where the highest frequency of EPCs can be found, the share of buildings without an EPC is seen as a barrier for any MMR implementation. MMR may be impossible to deploy unless the large majority of targeted buildings have an EPC.
- EPC frameworks differ across Europe, with various approaches that have led to a diverse set of instruments, differing in terms of scope, available information and impact. An MMR based on the national EPC schemes will, therefore, trigger a variety of impacts.
- The reliability of EPCs remains the subject of scrutiny and leaves room for improvement, especially if they were to credibly facilitate an MMR – the reliability, quality control and attainability of the threshold, which can be operationalised by an EPC rating, are the most important prerequisites for MMR.

[5] The main alternative to use the EPC as a proxy for the minimum standard, is to use the actual energy consumption/carbon use, which can be derived from smart meters and/or utility bills.
[6] X-tendo (2020) Energy Performance Certificates – Assessing their status and potential. European Commission – Horizon 2020 project. (Available: Online)

Potential impact on carbon emissions

Existing MMR have predominantly been focused on improving a building's energy performance during its use phase. There are good reasons for prioritising operational energy savings as, currently, this represents the main source of emissions in existing buildings. Renovating buildings, and increasing the overall energy performance, will reduce the energy required for heating and other end-uses, and thus also reduce the related carbon emissions. However, due to the incremental decarbonisation of energy supplies and the improvement of operational energy performance levels in buildings, the importance of embodied emissions has grown and will continue to do so. Considering the whole-life carbon impact in new constructions, and in renovations of existing buildings, is key to reduce the overall impact of the building sector.

As soon as lifecycle and embodied carbon data becomes more readily available, MMR could evolve to consider whole-life carbon emissions, including emissions from manufacturing and construction through to the end of life and disposal of buildings. An instrument like the building renovation passport, setting out a tailored renovation roadmap for an individual building, could identify the best path for the specific building to become "2050 ready", taking into account all related carbon emissions. The MMR can gradually include whole-life carbon considerations, defined concerning widely accepted lifecycle assessment (LCA) and CEN/TC350 standards, the Level(s) framework, Environmental Products Declaration and digital building logbooks.7

Integrating lifetime carbon emission considerations in MMR is a viable and worthwhile strategy. Significant carbon reductions are achievable however with a certain additional effort from the building value chain. It should be noted, however, that LCA is currently used to only a very limited extent in the building sector mainly due to the lack of a common industry standard and reliable datasets; addressing these gaps ahead of integrating carbon emission considerations in MMR should be a priority. Furthermore, as embodied carbon is a relatively less established metric than operational energy, more awareness-raising, training, guidance and simplification will be required to ensure successful implementation and market transformation.

Potential impacts on the real estate market

MMR can have significant effects on shaping business models and investment decisions in the real estate sector.

First, the introduction of MMR will mean that real estate managers and practitioners will find it easier to draw up decarbonisation strategies, identify reliable targets and actions to improve performance, as well as communicate and demonstrate compliance with MMR in a consistent way. Certainty around MMR makes the business case of investing in energy performance improvements more compelling.

Second, MMR will incentivise property markets to differentiate according to energy performance and will likely make the link between energy performance and market value (or investment worth) more visible and direct. In this sense, MMR can contribute to a price correction to reflect the performance of the building and/or affect the cash flow of non-compliant stock. Such effects are beneficial because often energy

[7] The setting of MMR thresholds could follow a similar approach to the EU sustainable finance taxonomy. The purpose of the taxonomy is to identify assets which are significantly contributing to climate change mitigation/adaptation, whereas the main purpose of the MMR is to identify the worst-performing segments. Setting the right MMR level will need to be proportional with compliance costs. Overall, considering the importance and urgency of improving the energy performance and decarbonising the building stock, the impact of compliance costs can be considered proportionate, especially given significant positive social and economic impacts the implementation of MMR can have.

performance is not adequately reflected in property valuations, investment and financing decisions, as well as the by real estate markets in general.

MMRs are primarily aimed at increasing the rate of upgrades to existing inefficient properties and raising awareness of energy-related issues. In the Netherlands, a significant increase of investments in renovation works of commercial properties has been observed in anticipation of the regulation – which requires office buildings to have an EPC of C – scheduled to come into force in 2023. On the other end, MMR will also provide a clear signal to the market that non-compliant assets are at risk of value depreciation or becoming stranded assets. Real estate investors and landlords may discriminate against buildings with low ratings within their portfolio strategies and seek to divest of stock that is either at risk or fails to meet the MMR standards (or is too expensive to renovate?). Others might acquire non-compliant properties and bring them up to standard if this is economically feasible. Properties in prime locations are less likely to be affected negatively in value terms by MMR, but all properties of poor specification and energy performance, which are expensive to upgrade, may face a value correction to reflect these.

Third, beyond the changing market preferences, lenders, investors and insurers may also start factoring in the risk implications of MMR. Better performing properties can attract cheaper financing, this could positively impact the value of such properties. Conversely, if financing and insuring sub-standard properties become more difficult or more expensive, it could negatively impact their market value.

The introduction of an MMR scheme is not regarded as counteracting article 17 (1) of the Charter of Fundamental Rights of the European Union (2012/C 326/02) on property rights. The introduction of an MMR will not deprive any property owner of his or her building. It rather serves the general interest since MMR are considered as a key instrument to decarbonize the building stock and secure sustainable energy supply to citizens of the European Union. In addition, the measures will lead to an increase in health and well-being of a significant share of the population and general increase of the property value, especially in view of rising carbon prices.

Social implications

The MMR has the potential to make sure all Europeans have a decent home and a bearable energy bill, by alleviating the worst-performing dwellings. 34 million households (or 13.90% of the population) are living in inadequate dwellings throughout the EU, defined as dwellings with leaking roofs, damp walls, etc. These buildings correlate strongly with the worst-performing buildings, which in addition to the health issues comes with high energy costs for the occupants. Renovating these buildings would reduce energy poverty levels as well as related health-care costs.

At the same time, policymakers need to consider the financial burden that comes with an MMR, as many landlords and private building owners will struggle to cover the extra cost. Therefore, affordability of renovations and prevention of energy poverty should be guaranteed by an enabling framework with financial measures for building owners and residents, especially the most vulnerable ones.

The landlords should be able to recoup the renovation investments through an increase in the rent which corresponds to the energy costs saved by the tenants. The extra cost for the tenants ought to be limited, in order to avoid adverse effects on the energy-poor (e.g. by causing ‘renovictions’).

Development since the EPBD Impact Assessment [SWD(2016) 414 final]

The potential and feasibility of MMR for existing buildings (Measure 1B: Oblige the renovation of buildings to reach a given standard before transactions), was evaluated in 2016 EPBD Impact Assessment. While viewed as effective in increasing the renovation rate and in reducing energy poverty, an MMR was considered not feasible due to "uncertain impact on the real estate market and probably stepping out of subsidiarity and proportionality limits of EU intervention". It was also noted that "detailed statistical data on national building stocks, linked with socio-economic indicators is a precondition for setting obligations on building renovation; however, this data is currently not available.".

The identified issues remain in place and have been discussed in this report. Below is a summary of these considerations.

1. The impact on the real estate market remains uncertain but the lessons learned we can draw at this point, suggest the impact will be positive. In the Netherlands, a significant increase of investments in renovation works of commercial properties has already been observed in anticipation of the regulation scheduled to come into force in 2023, which requires office buildings to have an EPC of C. Furthermore, MMR will also provide a clear signal to the market that non-compliant assets are at risk of value depreciation or becoming stranded assets. Having a clearer value differentiation and implicitly, a stronger link between energy performance and property value will help improving the business case and decision marking for investing in renovations.
2. The issue of subsidiarity and proportionality will depend on how the MMR is regulated and enforced by the EU. A uniform MMR would neither be in line with the subsidiarity and proportionality principles, nor desirable because the design options of an MMR ought to be adapted to the local context and needs. The experts consulted in this study, do not see the issue of subsidiarity and proportionality as major obstacle, if the MMR principle is established and enforced through the EPBD, and then designed and implemented by the Member States within certain defined boundaries. While a one-size-fits-all approach is not possible, the EU and its Member States should strive for as much harmonisation as possible because the signal to the real estate market would be stronger and more unambiguous, while also increasing synergies and learnings across borders.
3. The lack of reliable and granular data of the building stock is still a large obstacle. Most Member States rely on the EPC databases for information about their building stock, while few databases have been designed for this purpose. Since 2016, a large number of advanced EPC databases have appeared and evolved (e.g. Denmark and Ireland), together with digital building logbooks (Woningpas in Flanders and Casa+ in Portugal), material passports (Madaster in the Netherlands and Basta in Sweden) and a whole-life carbon database (Climate declaration database in Sweden). The Renovation Wave strategy set out to further improve the EPC databases and introduce digital building logbooks, which are needed to underpin the introduction of an MMR.

Identification of 6 archetypical MMR models

For this report, 29 MMR cases in Europe, the United States and Oceania have been identified and analysed. The approaches taken in these cases share many similarities but also differences. Six archetypical MMR models targeting the performance of entire buildings (i.e. not component-based) have been derived from the analysis of existing cases and stakeholder input. The models are archetypes or simplifications of how MMR can be designed, enforced and implemented.

MMR model 1: Progressive minimum energy performance requirements

- Building types: All buildings
- Metric: kilowatt-hours per square meter (kWh/m^2) based on asset rating (i.e. theoretical, as designed energy efficiency)
- Vehicle for implementation: Current energy performance certificates schemes (with improvements of reliability and data gathering and storage approaches)
- Long-term objective: gradual increase of minimum requirement until EPC B by 2050

MMR model 2: Progressive minimum carbon performance requirements

- Building types: All buildings
- Metric: Carbon dioxide emissions per square meter (CO_2/m^2) based on asset rating (i.e. theoretical, as designed carbon efficiency)
- Vehicle for implementation: Updated energy performance certificates schemes showing the operational carbon performance
- Long-term objective: gradual increase of minimum requirement until EPC B by 2050

MMR model 3: Progressive real carbon emissions budget

- Building types: Primarily larger residential and non-residential buildings
- Metric: Carbon dioxide emissions per square meter (CO_2/m^2) based on operational rating
- Vehicle for implementation: smart meter data and fuel mix
- Long-term objective: gradual increase of carbon budget until zero carbon by 2050.

MMR model 4: Mandatory improvements trigger by indoor environmental quality deficiencies

- Building types: Primarily schools, hospitals and offices
- Metric: Indoor environmental quality (air quality, thermal comfort, ligthing, acoustics) standards
- Vehicle for implementation: energy audit
- Long-term objective: none

MMR model 5: Progressive implementation of pre-defined renovation steps based on a building renovation passport

- Building types: All buildings
- Metric: Carbon dioxide emissions per square meter (CO_2/m^2) based on asset rating and eventually consider whole-life carbon aspects
- Vehicle for implementation: building renovation passport (a detailed and tailored renovation roadmap for the individual building based on an audit)
- Long-term objective: the steps of the roadmap ought to align with the 2050 objectives

MMR model 6: Renovation obligation linked to real estate transactions for all building non-compliant in 2050

- Building types: All buildings
- Metric: kilowatt-hours per square meter (kWh/m^2) based on asset rating (i.e. theoretical, as designed energy efficiency)
- Vehicle for implementation: current energy performance certificates. All buildings not being "2050-ready", must be upgraded in conjunction with property transfer
- Long-term objective: all buildings are moving towards the long-term target

Figure 1: Six archetypical MMR models

Potential paths forward

Europe's efforts to support the uptake of MMR for existing buildings can be described in different policy pathways. The policy pathways outline a sequence of policy actions, legislative and non-legislative, together with supporting measures that over time achieve a set of pre-defined objectives. The existing cases demonstrate the many ways an MMR can be designed and implemented. While there may be numerous plausible paths forward, four pathways have been derived to represent the most realistic approaches. Much of the impact of the different pathways will, in the end, depend on how it is enforced by the EU and what is required by the Member States.

There is no silver bullet for how MMR can be implemented and enforced. It needs to combine various key ingredients, which can be different for the various Member States, while continuously improving the policy based on new and emerging lessons learned. Successful MMR introduction must be supported by a wider policy framework. The analysis of existing cases shows that the introduction of MMR must be accompanied by several supportive measures depending on the local context, including:

- Financial support schemes to make the requirement more palatable for key stakeholders and lessen the potential upfront financial burden put on certain groups. Vulnerable citizens like the energy-poor should not experience this as an extra burden to avoid "renovictions". Many people living in the worst-performing buildings, which would be subject to an MMR, are vulnerable to a cost increase. Real estate investors and owners considering deep renovations should be incentivized, through instruments like subsidies and green bonds, to go beyond the minimum requirements and to avoid a steep increase in demand just before the compliance date.
- Skills and capacity of the construction value chain. The renovation boost that will be triggered by MMR will require a skilled workforce, while the shortage of workers has been flagged as a constraint, especially in some Member States. Investments are needed in training and capacity building, as well as in attracting new talents and improving the image of the construction sector, to make sure there are enough workers with the right skills, to deliver the renovation wave.
- Public awareness and acceptance are key for effective implementation of MMR. People should be aware of and understand the requirement as well as the purpose and clear short and long-term benefits behind them in terms of climate mitigation and alleviation of energy poverty. Lessons learnt from existing cases show that it is difficult to get the right information out there to the citizens. Support can be given to the Member States to carry out tailored communication campaigns and integrated renovation services, such as one-stop-shops, to make the renovation journey smoother.

The following pages describe four policy pathways, outlining the main approaches for how MMR can be introduced and enforced in the EU.

Policy pathway 1: Progressive minimum energy performance requirement

Policy Pathway 1 aims to alleviate the worst-performing building in terms of energy efficiency by introducing a progressive minimum energy performance requirement for the existing buildings. The pathway has been designed to utilise existing infrastructure (esp. the EPC schemes) and existing directives (esp. the EPBD). The boost in demand for energy renovations will drive change in the construction value chain by requiring an improvement of the worst-performing building segments.

Policy pathway 1 sets progressive minimum energy performance requirements (expressed in kWh/m^2/year) and can, therefore, build on the existing policy framework. This MMR may be deployed via a new article in the EPBD and linked to the EPCs and long-term renovation strategies (LTRS).

The existing cases show that successful MMR must be integrated into a wider policy framework and be based on long-term progressive enforcement perspectives. To make policy pathway 1 effective, the EU and its Member States must support it through:

- Improvement of the penetration, reliability and awareness of EPCs, for example through higher and more harmonised requirements by the EU.
- Investment in skills in the construction value chain to make sure there are enough certified workers to carry out the additional work.
- Promoting the deployment of appropriate financing schemes, to ensure the accessibility and affordability of the renovation investments.
- Directing financial support to limit the negative effect on vulnerable groups, as well as to incentivise people to upgrade their building beyond the minimum requirement.
- Facilitating forums for good practice exchange.
- Investing in awareness-raising activities among the public.
- Setting up a systematic approach to address the 'performance gap'[8]

Pros	Cons
+ Relatively easy to implement + Builds on existing cases + Easy for end-users to grasp	- The performance gap is a risk - Risk that whole-life carbon emissions may be overlooked if not addressed by another measure

[8] The performance gap, referred to here, is the disparity that can be found between the energy use predicted in the design stage of buildings and the energy use of those buildings in operation.

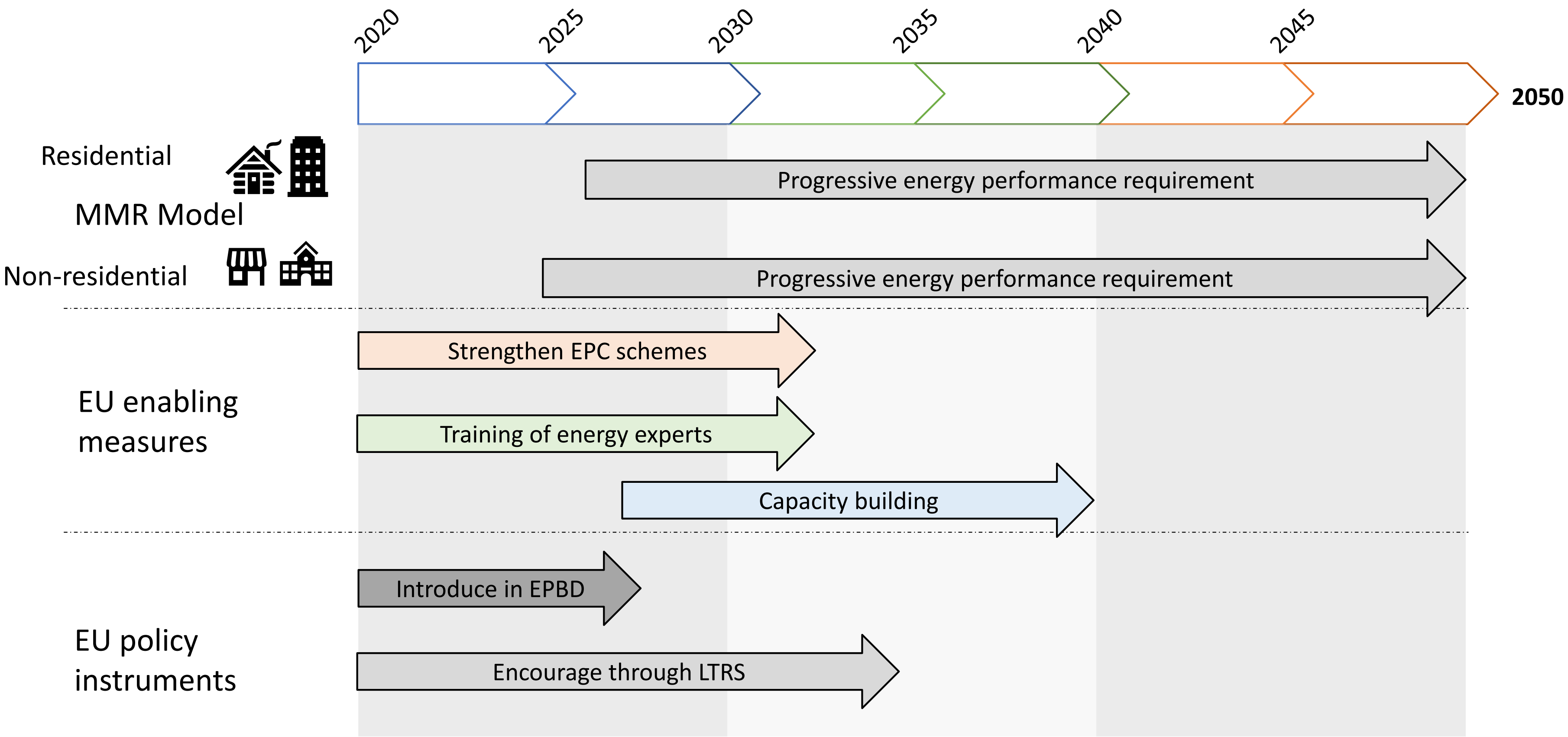

Figure 2: Policy pathway 1 - Timeline

Policy pathway 2: Progressive minimum carbon performance requirement

Policy pathway 2 aims to get carbon emissions related to operational energy consumption down to zero by 2050. MMR linked to carbon emissions, instead of energy performance, can better align the requirement with the long-term climate objectives, which are expressed in carbon emission levels. This MMR can drive increased demand for renovations, with an optimal balance between energy efficiency and renewable energy investments.

Policy pathway 2 sets progressive minimum carbon performance requirements (expressed in CO_2/m^2/year and relating to operational energy consumption). For residential buildings, the pathway foresees that EPCs are updated to feature the carbon performance of the building more reliably. For non-residential buildings, the carbon performance is derived from the actual energy consumption (e.g. as displayed by smart meters) and the local energy mix and the CO_2 emission factor. Carbon performance, in this pathway, focuses on the emissions as a result of the operational energy consumption. It does not include embodied carbon emissions, which a whole-life carbon approach would do (see Policy pathway 3). This carbon-oriented MMR would, however, require a broader regulatory framework.

To make policy pathway 2 effective, the EU and its Member States must support it through:

- Updating EPCs to feature the building's carbon performance, while also improving the instrument's penetration, reliability and awareness. Under the EPBD, Member States already have the possibility to define additional numeric indicators to express the energy performance of buildings, including in terms of carbon emission produced (expressed in kgCO2eq/m^2/year), in addition to primary energy use.
- Exploring how to set a carbon performance requirement that balances energy efficiency and renewable energy investments.
- Investing in skills, communication, financial support and good practice forums, as described under policy pathway 1.

Pros	Cons
+ Aligned with 2050 target + Easy for end-users to grasp + Cost-optimal balance between energy efficiency and renewables	- Requires considerable revisions of the existing legislative basis - Some multiple benefits (better comfort, health and productivity gains) of energy efficiency improvements at risk of being missed - Whole-life carbon emissions are not included

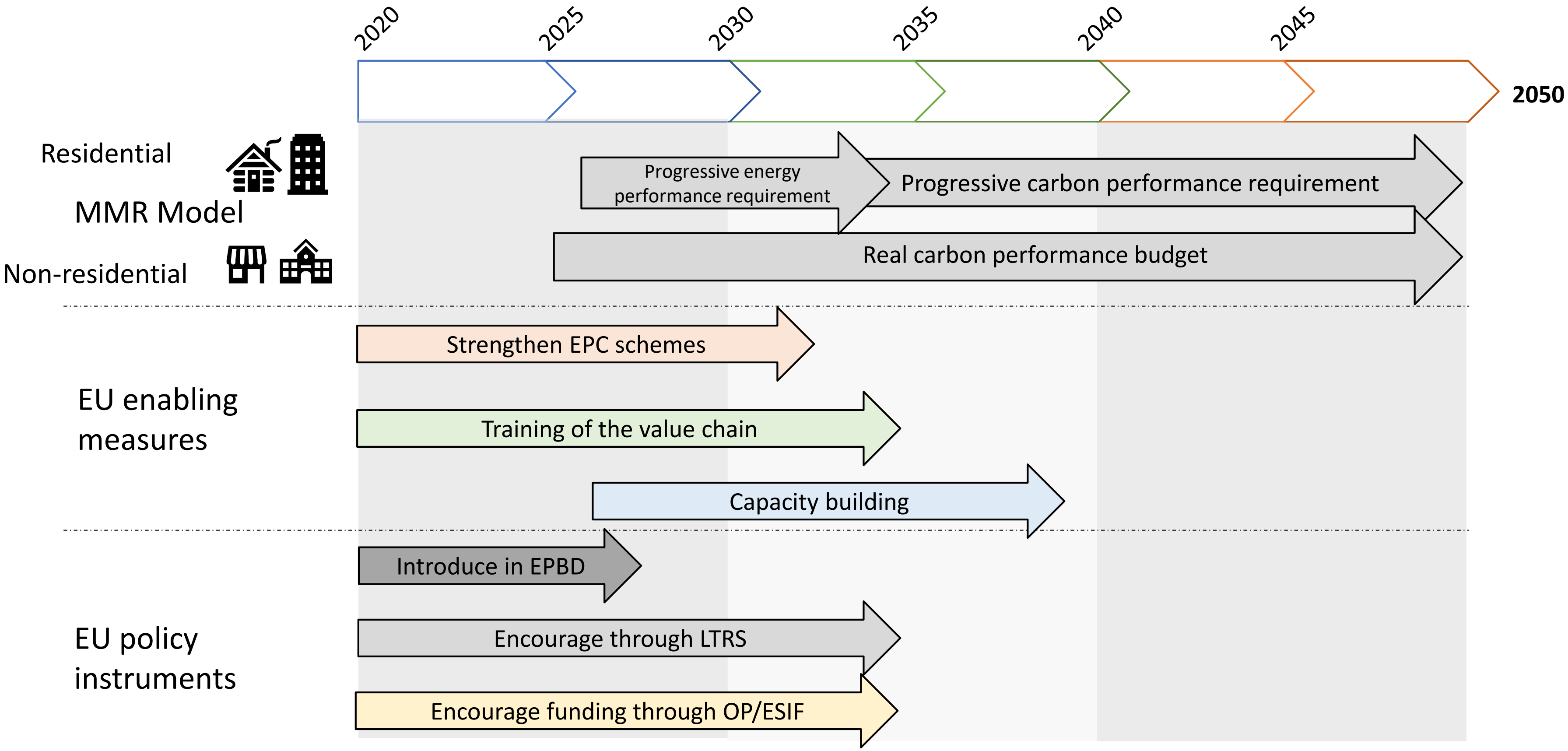

Figure 3: Policy pathway 2 - Timeline

Policy pathway 3: Progressive minimum carbon performance requirement, considering whole-life carbon aspects

Policy pathway 3 aims to get all carbon emissions down to zero by 2050 by integrating all related carbon emissions. An MMR linked to carbon emissions can better align the requirement with the long-term climate objectives, yet is more complex to design and put in practice, because there is no common standard[9] for how data can be gathered and stored, and no database of whole-life carbon data[10] that can be used for benchmarking purposes. A whole-life carbon standard would have circularity as a key principle and would tend to favour the reuse of buildings and their materials as much as possible, and influence design decisions in both renovations and new constructions.

Policy pathway 3 sets progressive minimum carbon performance requirements. The carbon performance requirement should gradually go on to also consider lifecycle performance when the renovation plan is developed for the individual buildings. The pathway relies on reliable building data being available and attainable, and tailored renovation recommendations for the end-users, which can be ensured by the introduction of digital building logbooks[11] and building renovation passports[12]. The whole-life carbon aspect might influence the renovation stages of the building, what materials and strategies are suggested and when the measures will be carried out.

To make policy pathway 3 possible, the EU and its Member States must support it through a number of enabling actions.

Immediate actions

- Collecting and storing information on buildings' life-cycle emissions, based on a common operational standard is needed and would increase transparency and awareness about embodied carbon. The life-cycle information should be compiled in a publicly available database, starting with public and new buildings.
- Introducing a whole-life carbon performance indication in the EPC and their renovation recommendations. The EPBD already makes it possible to the Member States to express the building performance using indicators additional to primary energy. One indicator could be whole-life carbon using a light LCA approach.
- Introducing and continuing the development of building renovation passports and digital building logbooks – these are an important link to enable whole-life

[9] The EU Level(s) framework is a protocol that brings together all relevant standards on whole-life carbon (and other aspects). The framework could be evolved to enable benchmarking of the whole-life carbon performance and thus support this policy pathway. The European Standard [EN 15978] specifies the calculation method, based on LCA and other quantified environmental information, to assess the environmental performance of a building, and gives the means for the reporting and communication of the outcome of the assessment. Several other European and ISO standards do address whole-life carbon and sustainability of buildings. See compilation in Bionova Ltd (2018) The Embodied Carbon Review (Available: Online). While most existing whole-life carbon-standards are considered too "high-level" by industry professional, some are already considered operational and commonly used, one example is RICS (2017) RICS professional statement: Whole life carbon assessment for the built environment. (Available: Online).

[10] Sweden is currently introducing a climate declaration requirement for new constructions, which will enter into force on 1 January 2022 (see link). It includes "developing a national database containing climate data and taking measures to promote carefully-considered requirement specifications from a life-cycle perspective". Databases like this are needed to support the inclusion of whole-life carbon considerations in new buildings and renovatin of existing buildings.

[11] A digital building logbook is a common repository for all relevant building data. It facilitates transparency, trust, informed decision making and information sharing within the construction sector, between building owners and occupants, financial institutions and public authorities.

[12] A Building Renovation Passport is defined as a document outlining a long-term step-by-step renovation roadmap for a specific building, resulting from an on-site energy audit and fulfilling specific quality criteria and indicators established in dialogue with building owners. As the passport is based on a detailed energy audit it is well placed to integrate LCA considerations. See European Commission's Technical study on the possible introduction of optional building renovation passports (see link)

carbon assessments and informed decision-making and could store all the relevant life-cycle building data.
- Introducing LCA reporting requirements for larger public buildings and new constructions
- Significant investments in skills, communication, financial support and good practice forums, as described under policy pathway 1.

Subsequent actions

- Exploring how LCA and related validation/compliance can be included cost-effectively. Pilot cases can help testing and validation of the approach.
- Continuing the development of Level(s)[13] which is based on established LCA assessment tools and, implicitly, whole-life carbon.
- Introducing LCA reporting requirements for all buildings in connection with EPC

Existing cases to learn from:

No existing case is currently integrating whole-life carbon considerations.

Pros	Cons
+ Takes whole-life carbon into account and thereby contributes further to the national carbon reduction targets + LCA will steer the market towards more sustainable options, resulting in wider benefits	-Setting up the whole-life carbon data infrastructure will require time and considerable investments - Requires considerable revisions of the existing regulatory framework - More difficult for homeowners to grasp and more difficult to communicate broadly - Technically and administratively more complex - Require additional training for energy experts and construction professionals

[13] Level(s) is a common European approach to assess and report on the sustainability of buildings.

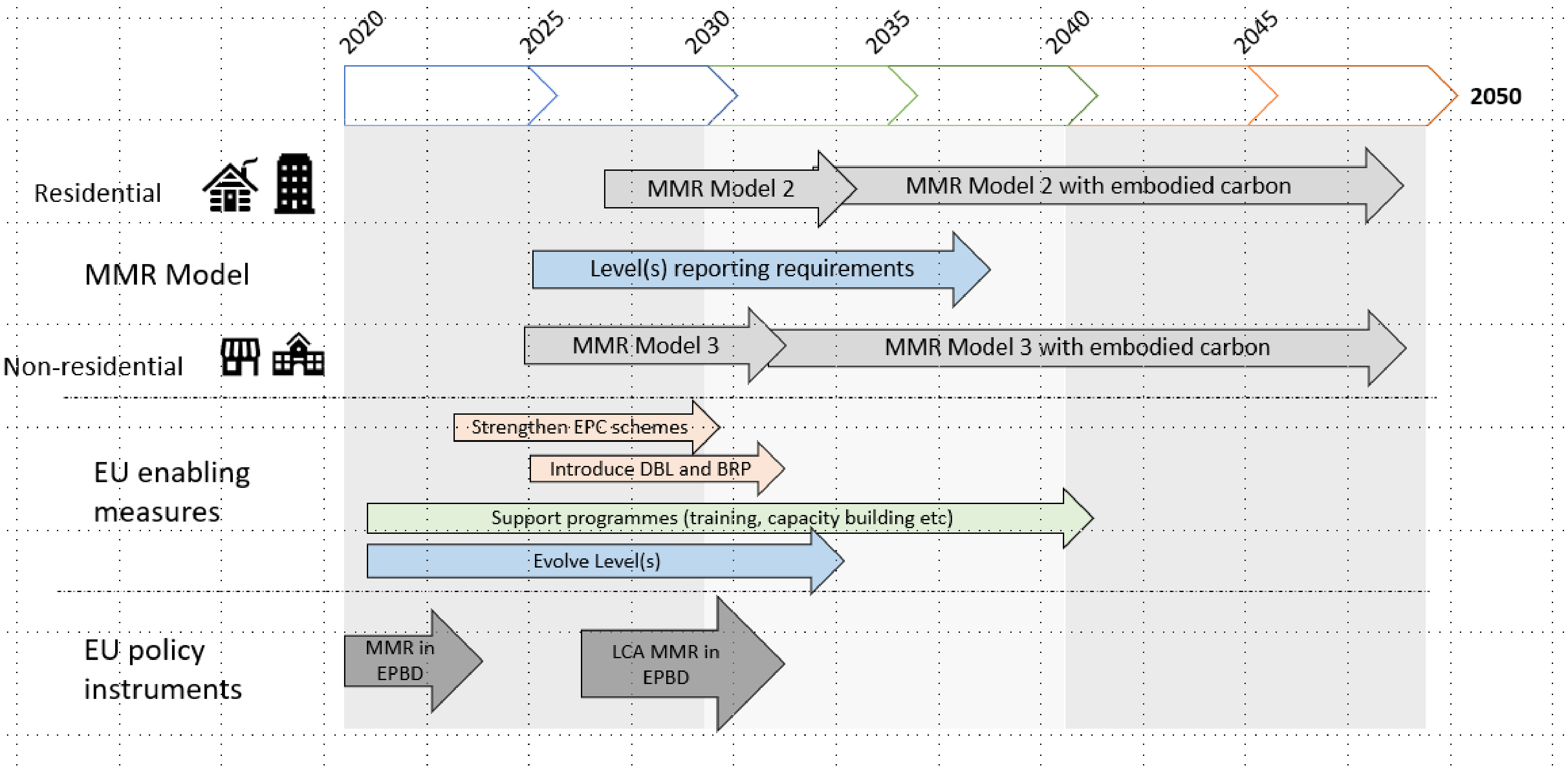

Figure 4: Policy pathway 3 - Timeline

Policy pathway 4: Moving all buildings towards the objective of a decarbonised building stock by 2050

The focus of the policy pathway 4 is to capture the key trigger points in a building's lifetime in addition to progressive enforcement of minimum requirements. The pathway goes beyond tackling just the worst-performing buildings, as it applies to 97% of all buildings[14]. Trigger renovation concerning property transfers could foster an effective and smooth transition towards the 2050 objective. The additional cost for the property buyer to upgrade the building's EPC label with 1-2 steps, will amount to a fraction, on average, of the cost of buying the property, which can be incorporated in the total cost. Prospective building owners would be made aware of this requirement and can thus plan accordingly. A link with energy efficiency mortgages[15] could reduce the extra financial burden of this requirement. Policy pathway 4 combines two MMR models:

1. The first sets a renovation obligation for all properties that are being sold and do not already have an EPC label A (or what rating is required for the specific building to be compliant with the 2050 requirement).
2. The second set progressive minimum energy performance requirement for operational energy consumption for all buildings to make sure that all the worst-performing buildings are being upgraded (as in policy pathway 1).

To make policy pathway 4 effective, the EU and its Member States must support it through:

- Updating EPCs and improving the instrument's penetration, reliability and awareness.
- Improving the information available on the real estate market and raise awareness of all stakeholders involved in real estate transactions.
- Investing in skills, communication, financial support, and good practice forums, as described under policy pathway 1.

Pros	Cons
+ Boosts the renovation activities + All buildings (except the highest-performing ones) must comply, which can increase the overall acceptance	- Possible negative effect on the housing market, as the buildings would be relatively more expensive with this requirement - Confusing mix of different requirements, challenging to understand and communicate

[14] See BPIE's analysis of EU's building stock based on EPC data, where only 3% of existing buildings have an EPC label A.

[15] An energy efficient mortgage is a loan product that allows borrowers to reduce their utility bill costs by allowing them to finance the cost of incorporating energy-efficient features into a new purchase. See: https://energyefficientmortgages.eu/

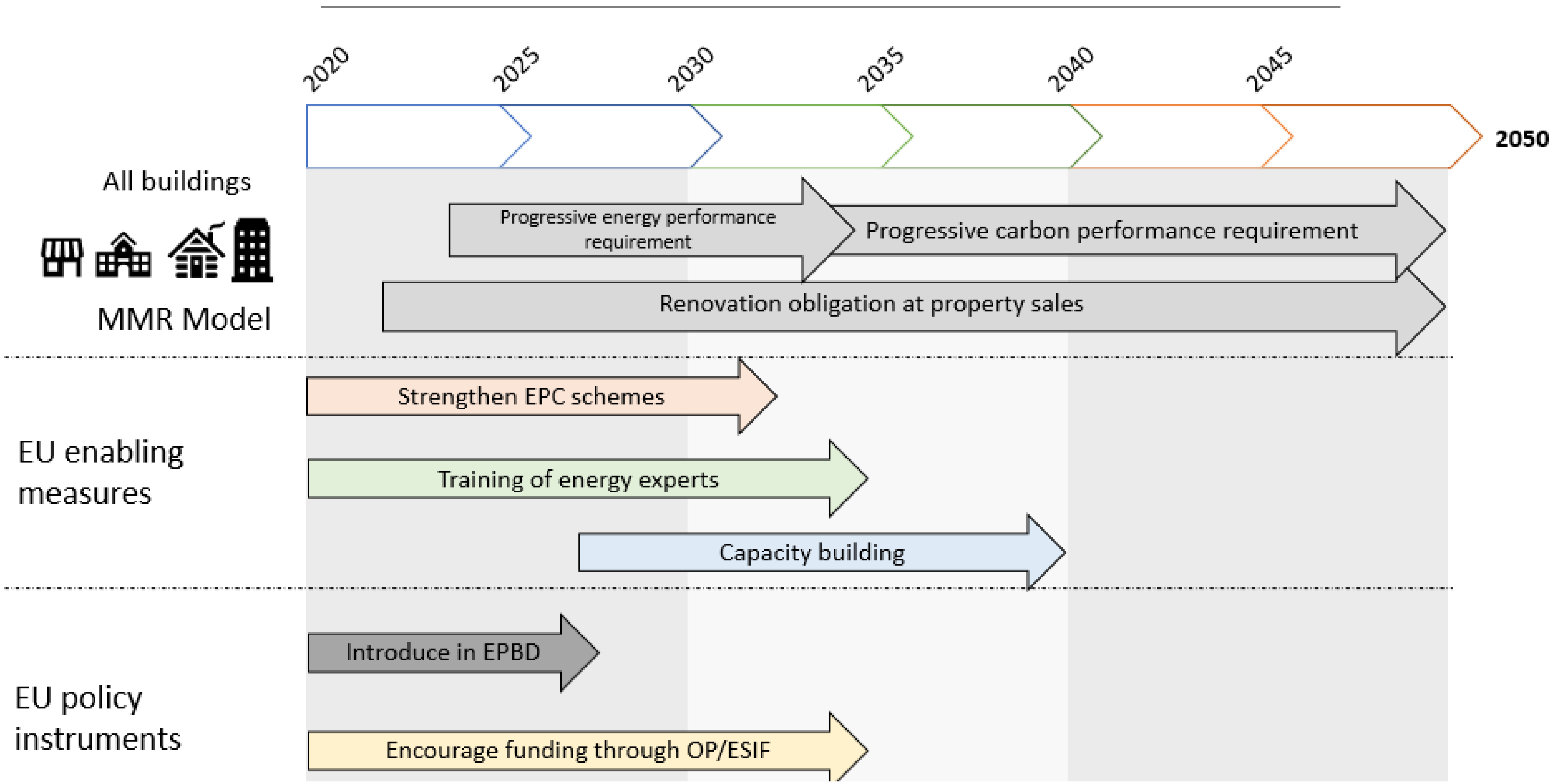

Figure 5: Policy pathway 4 - Timeline

Key lessons learned

MMR can be a powerful tool to address both the low rate and depth of renovations. Experiences from the Member States with MMR already in place provide useful lessons for the future design of the instrument, which can be tailored to the different segments of the building stock and ownership tenures. Coupled with adequate financial support, MMR can contribute to decent homes for the more vulnerable.

- **A clear overview of the building stock is the starting point to design effective MMR**. This includes, for example, having a comprehensive understanding of the energy and climate performance of the building stock, particularly the worst-performing buildings, the different tenure statuses as well as of the different building typologies, to which the obligation will apply. Ideally, MMR is linked to already established frameworks, like the EPCs in Europe or the Energy Star Portfolio Management tool in the USA.
- An effective MMR needs to be embedded in a **wider policy framework**, including adequate and targeted financial support, capacity building and information measures.
- **EPC schemes need to improve and evolve in scope** to effectively facilitate an MMR built around them, including their reliability, comparability, availability as well as data gathering and the functionality of EPC databases.
- While MMR is introduced to improve the worst-performing buildings, **voluntary standards** can be defined up to the 2050-standard (e.g. a net-zero carbon building) and linked with additional financial support. The MMR can then be progressively tightened over time until the 2050-standard has been reached.
- **Different building types can be treated differently within an MMR scheme**. Larger, non-residential or public buildings could lead by example by having to comply with the MMR before other building typologies. The MMR for these buildings could also be more sophistically elaborated, as better data gathering opportunities and more granular data generally exist.
- Special attention must be paid to **vulnerable citizens** who live in inadequate dwellings to make sure they are not "punished" twice. The risk of "renovictions", where people cannot afford to pay their rent, due to rent increases after renovations should be evaluated and addressed by an appropriate supporting framework, such as targeted financial support and avoiding disproportionate rent increases.
- **Stakeholder involvement is essential from the very early stages** in the design of an MMR and to build understanding, support and acceptance around the policy. Policymakers can gather valuable insights and tailor MMR design choices to the characteristics of local buildings, different tenures, and the built environment.
- Communicate on **multiple benefits** of energy renovations (beyond carbon and energy), such as better comfort, health, productivity, and overall wellbeing.
- Gradually including **carbon performance and embodied carbon metrics** can contribute significantly to achieving GHG emission reductions, though at the short term challenges remain with regard to data gathering and benchmarking.
- **The MMR ought to be coupled with tailored renovation advice** (such as a building renovation passport) to avoid technical and economical lock-in effects.
- Ensure **sufficient lead time** and **administrative capacity** to implement MMR. The public authorities must show that they are serious with the enforcement but also give the market time to adapt. In addition, the availability of a skilled workforce is also an important precondition.
- **The policy design should be aimed at simplicity**. Too complex regulation, such as many exemptions, make the MMR enforcement less likely to succeed.

CONTENTS

TERMINOLOGY

Building renovation passport (BRP) - A BRP provides a long-term, tailored renovation roadmap for a specific building, following a calculation based on available data and/or an on-site audit by an expert. The instrument identifies and outlines the deep renovation scenario(s), including steps to implement energy-saving measures that could improve the building's performance to a significantly higher level over a defined period. The instrument can be complementary to energy performance certificates and/or combined with digital building logbooks.

Building stock – All buildings, residential and non-residential, that exist in a certain area, which can be regional, country-wide or the whole European Union.

Final energy consumption – Total energy consumed by end-users, such as households, industry, and agriculture. It refers to the energy that reaches the final consumer's door and excludes that which is used by the energy sector itself.

Embodied carbon - Carbon emissions associated with materials and construction processes throughout the whole lifecycle of a building

Enabling policy framework – Comprises policies that are not directly related to the mandatory minimum requirement but enable it to function (more effectively). The enabling policy framework can include measures like training of experts, financial support, communication, and awareness-raising activities.

Energy Efficiency Directive (EED) – Under this directive, EU countries are required to use energy more efficiently at all stages of the energy chain, including energy generation, transmission, distribution, and end-use consumption. The 2018 amendments outlined a target for 2030 to improve energy efficiency by at least 32.5% for the EU, compared to 2007 levels.

Energy performance certificate (EPC) – A rating scheme indicating the energy performance of a building in the European Union. Each Member State (and, in certain cases, region) has developed its EPC according to the framework given by the EPBD [2010/31/EU – Article 2 (12)].

Energy Performance of Buildings Directive (EPBD) – The objective of this directive [2010/31/EU] is to promote the improvement of the energy performance of buildings within the Community, taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness.

Digital building logbook (DBL) - A DBL is a digital repository for all building-related data on individual buildings, which facilitates information sharing within the construction sector, and between building owners and tenants, financial institutions and public authorities.

Indoor environmental quality (IEQ) – A general indicator of the quality conditions inside a building. It most commonly refers to indoor air quality, thermal comfort, aesthetics, ergonomics, biophilia, acoustics and lighting. Several of these elements have a significant impact on our health, comfort, and productivity.

Level(s) - a new European approach to assess and report on the sustainability performance of buildings, throughout the full life cycle of buildings.

Lifecycle assessment (LCA) – The methodological framework to quantify all environmental impact caused during the life cycle of a building.

Long-term renovation strategies (LTRS) – These strategies must be established and implemented by the Member States according to Article 2a of the EPBD to support the renovation of the national stock of buildings into a highly efficient and decarbonised building stock by 2050, and will form part of Member States' integrated national energy and climate plans.

Mandatory minimum requirements (MMR) – Examples of MMR for existing buildings include requiring a minimum EPC class for sale, rental or other property transactions or that a building must comply with a certain energy performance level by a given year .

Minimum energy performance standards (MEPS) – also referred to as mandatory minimum requirement (MMR – see above), MEPS are regulations that mandate certain buildings within a defined territory to meet a certain performance standard, by a specified compliance date or according to natural trigger points in the building's lifecycle (e.g. time of sale)

MMR model - The principal archetypes of mandatory minimum requirements, describing the different MMR design options, including policy design, targeted building typologies or trigger points.

Operational energy/carbon use - The energy/carbon use associated with energy used to operate the building (e.g. energy for heating and hot water)

Policy package – The policy package is a derived policy approach including a policy option, appropriate EU policy tools and a tailored enabling policy framework.

Residential building – A building at least half of which is used for housing purposes. If less than half of the overall useful floor area is used for housing purposes, the building is classified as a non-residential building following its purpose-oriented design. The residential building category can be further divided, e.g. depending on the ownership and the tenure status.

Whole-life carbon - Emissions from all lifecycle phases of a building, encompassing both embodied and operational carbon emissions

Whole-life carbon consideration – Taking into account all related emissions in the decision-making process, such as BRP or renovation advice.

1. INTRODUCTION

The latest review of the Energy Performance of Buildings Directive (EPBD) [2018/844] sets out to achieve a 'highly energy-efficient and decarbonised building stock' by 2050. The directive obliges Member States to develop and implement long-term renovation strategies (LTRS), including milestones and forthcoming policy measures to achieve the long-term objective. The impact assessment of the EPBD declared that mandatory minimum requirements (MMR) could have a significant impact on increasing renovation activity and trigger energy savings across the EU. It was, however, not retained in the preferred options due to concerns regarding practicality.

The Renovation Wave strategy, published on October 14 2020, is comprehensive and far-reaching. Its premise is to contribute to a higher 2030 climate target and decarbonise the building sector, a wide range of policies, measures and tools must be put in place at all levels to overcome existing barriers and mobilise all actors, including citizens, local authorities, investors and the construction value chain.

The Renovation Wave rightly highlights many different intervention points, with a clear timeline. One of the central intervention points is to introduce "mandatory minimum energy performance standards as part of the revision of the Energy Performance of Buildings Directive (EPBD) by the end of 2021".

This report presents the findings of the current study which has explored the scope, timeline and impact of an MMR framework at EU level. While relevant links are made to the Renovation Wave, and its provisions, throughout the report, it was largely developed before the Renovation Wave strategy was disclosed.

Setting up MMR for the entire building stock (on a regional or country level), or specific parts of it (e.g. public or rental buildings), can be a very effective instrument to achieve fast and long-lasting emissions reductions.[16] MMR can be designed to specifically target deep renovations and be aligned with the long-term objective for the built environment. The best-known existing MMR approach is the Minimum Energy Efficiency Standards introduced in England and Wales, where landlords are not allowed to rent out dwellings with an EPC class lower than E. Similar approaches exist in France (though not enforced yet), the Netherlands (EPC C for office buildings), in the Flanders region of Belgium (a mix of minimum requirements for building equipment and the envelope), as well as in the United States where cities like New York are frontrunners (with carbon emission budgets/thresholds for larger buildings).

Practical implementation across the EU is, however, challenging at present. The energy performance certificates (EPC) framework[17] would be the most obvious reference point for introducing MMR. But the comparability across Europe concerning the EPC, in terms of general availability, calculations, control and data availability, needs further improvement. Subsidiarity issues also come with this instrument, suggesting that the EU policy can be a framework only, leaving enough flexibility for Member States' implementation.[18]

MMR can also be linked to various trigger points, such as property transfers or non-energy renovation works. According to Article 2a (1)b of the EPBD, Member States will have to identify cost-effective approaches to renovation, including potentially relevant

[16] C40 (2019) "How to set energy efficiency standards for existing buildings". C40 Cities Climate Leadership Group. (Available: Website)

[17] The certificates play a central role in the EPBD [2010/31/EU] as EU countries are asked to provide information on the certificates and inspection reports. In addition to purpose and objectives, the certificates should also disclose cost-effective ways and, where appropriate, available financial instruments to improve the energy performance of the building to the owners or tenants of the buildings.

[18] See e.g. European Commission (2016) Impact Assessment of the EPBD 2016, [SWD (2016) 414 final] (Available: Online)

trigger points in their LTRS. The LTRS are thus an opportunity for the Member States to consider this instrument and how to best introduce it[19].

The objective of this study is to analyse the relevance, feasibility, and possible scope of additional measures at EU level in favour of MMR. These may be related to sale, rental or other property transactions based on a minimum EPC class, but are not limited to this. They may also include accompanying measures that help to overcome barriers for implementing MMR related to practical implementation and subsidiarity.

Existing MMR cases provide some useful learnings

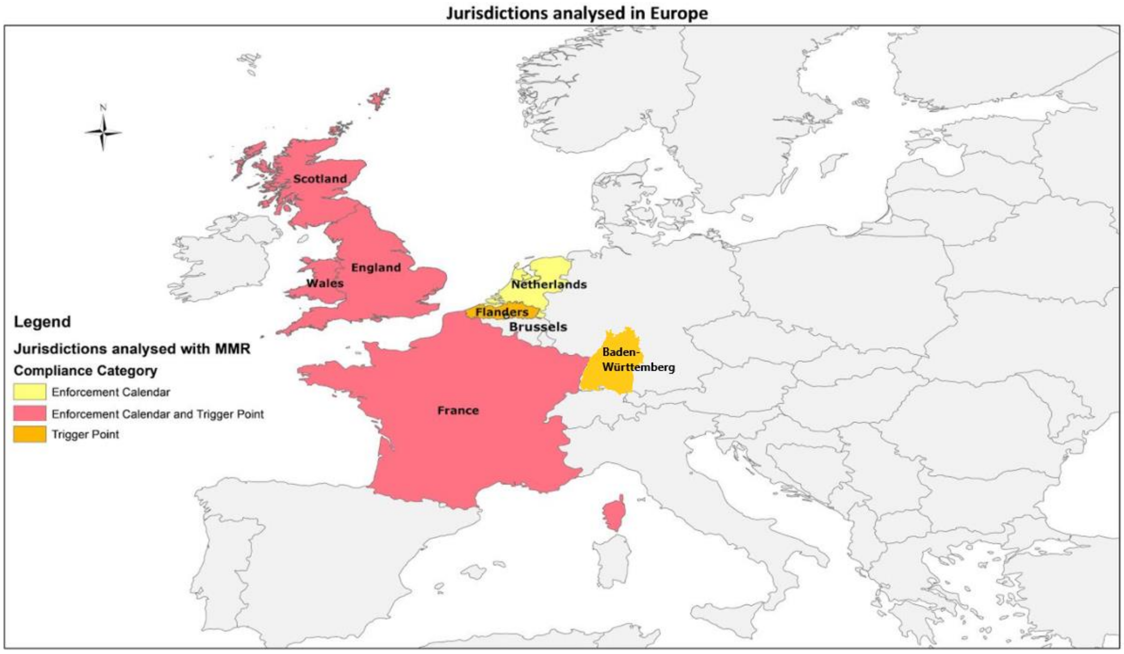

Figure 6: Jurisdictions analysed in Europe

In recent years MMR for existing buildings has received increasing attention as a powerful policy tool to decarbonise the building stock in Europe and the USA. The MMR field is dynamic and continuously developing and policymakers have designed and implemented various forms of MMR in different regions of the world. The overview of cases analysed in Europe is presented in Figure 6 and Table 1 below. Appendix 1 provides an overview and in-depth analysis of MMR in Europe, the USA and Oceania.

In North-West Europe, the most common trend is to introduce MMR linked to EPCs, which fall in the category of 'asset rating'[20]. Buildings should achieve a minimum EPC rating at specific trigger points in the building lifetime or by predefined years. Examples can be found in the Netherlands, Belgium, France and the UK.

Policy innovation is also taking shape in local and regional jurisdictions. In Brussels, Belgium, the planned MMR is setting out a progressive implementation of renovation measures based on a building renovation passport (BRP). In this passport, a stepwise approach tailored to a specific building is devised that outlines the required measures to achieve a decarbonised building by 2050. In Baden-Württemberg, Germany, they have introduced a renewable heating obligation, requiring building owners to get, at

[19] BPIE's (2020) review of the Member States' LTRS shows "that Member States need to immediately step up effort to rapidly decarbonise the building stock. Many Member States still do not seem to prioritise action in the building sector, which is central to climate mitigation and to improving living conditions of Europeans, with the urgency that is needed". (Available: Online).

[20] Asset rating determines the energy performance of buildings based on calculated estimates, whereas operational rating determines performance on actual energy consumption.

least, 15% of their heating from renewable energy sources. The requirement is triggered when the individual heating systems is old and needs to be replaced[21].

Name/description of requirement	Location	Building type	Metric	Effective/ Enforced	Compliance category
Mandatory progressive implementation of renovation steps	Brussels, Belgium	Residential	Asset rating	2030	Enforcement calendar
Mandatory energy consumption reductions (PLAGE)	Brussels, Belgium	Non-residential	Operational rating	2019	Enforcement calendar
Minimum energy performance standard for all tertiary buildings[22]	Flanders, Belgium	Non-residential	Asset rating*	2030	Change of owner
Minimum energy performance standard for residential buildings	Flanders, Belgium	Residential	Asset rating	2021	Change of owner
Minimum quality standards for basic comfort, safety and health	Flanders, Belgium	Residential	Asset rating	2021	Complaints by tenants
Travaux embarqués (embedded work)	France	All	n/a	2017	Implementation of other works
Minimum energy standard	France	Residential	Asset rating	2028	Enforcement calendar/ change in tenancy
Tertiary Renovation Decree	France	Non-residential	Operational rating	2030	Enforcement calendar
Minimum Energy Efficiency Standard	England and Wales	Residential	Asset rating	2018	Change in tenancy/Enforcement calendar
Minimum Energy Efficiency Standard	Scotland	Residential	Asset rating	2020	Change in tenancy/Enforcement calendar
Minimum standard for all office buildings	Netherlands	Non-residential	Asset rating	2023	Enforcement calendar
Renewable heating and efficiency obligation	Germany, Baden Württemberg	Residential and most non-residential	Asset rating	2008 (with updates 2015)	Trigger point

Table 1. Overview of the MMR cases in Europe

[21] Pehnt, M et al. (2019) Evaluating the renewable heating and efficiency obligation for existing buildings – insights into the mechanisms of mandatory building requirements. ECEEE summer study. (Available: Online)
[22] All non-residential and non-industrial buildings.

Lessons learned from the case studies

MMR are already existing in many shapes and forms, which shows the flexibility/adaptability of this policy concept. To allow for a comparison, MMR can be categorised based on characteristics like the *enforcement framework*, *metrics used*, *trigger points*, awareness and *building segments targeted*, (see these characteristics described for several case studies in Appendix 1). The following paragraphs are summarizing the main lessons learned from existing cases.

Metric

The most common metrics are energy performance (kWh/m^2) and carbon performance (CO_2/m^2). The main difference is that the energy performance metric is not dependent on the fuel mix, while the carbon metric is aligned with long-term climate objectives. While energy performance is the most common metric, especially in Europe, New York City's MMR is targeting carbon emissions derived from actual energy consumption. Table 2 below summarises some pros and cons of different approaches.

In the EU, the EPC label is commonly used as a proxy for the energy efficiency rating (see the UK, France and the Netherlands). Similarly, in the US, the Energy Star score is used in several jurisdictions to indicate the performance level.

Approach	Pros	Cons
Energy consumption	Can use established programs such as the EPC and American ENERGY STAR rating. Many users are already familiar with these metrics and tools.	It only addresses energy use, harder to develop targets that can achieve the long-term objectives (i.e. a decarbonised sector).
GHG emissions	Addresses the objective of reducing GHG emissions. Easier to set and align with long-term goals.	If emissions from the grid are included in the calculations, this is typically nothing the building owners can address.
	Enables more flexibility, as energy efficiency and renewables can be combined to cost-optimally reach the objective.	Could de-emphasize energy efficiency if "offsets" are widely available.

Table 2: Pros and cons of the most common performance standard approach. Source: ACEEE, 2020[23].

One underlying issue is whether the metric should be based on measured energy and carbon use (i.e.actual consumption) or an asset score (i.e. theoretical calculation). The operational metric is heavily influenced by user behaviour, which can change with new owners, but also reflects the actual situation. The benefit of an asset score is that the comparison between buildings becomes fairer, even though the actual energy/carbon use can differ quite substantially. Asset score is most used in the EU (commonly underlying the EPCs), yet there are exceptions like the French 'Décret Tertiaire', which sets targets based on measured consumption, for the targeted tertiary buildings. Measured energy/carbon use is the preferred metric in the US.

[23] Nadel, S & Hinge A (2020) Mandatory Building Performance Standards: A Key Policy for Achieving Climate Goals. ACEEE (Available: Online)

While this study focuses on whole-building MMR, some minimum standards are defined as the presence of a minimum set of building fabric and heating system measures.

Monitoring and enforcement

The requirement must be perceived as impartial and rational (and achievable?). Action from building owners might be limited if the enforcement is perceived as flawed.

A database of all buildings and their performance enables a better compliance check. In Boulder, the landlords need to renew their license every four years and were given two license-renewing-cycles to comply[24]. The EPC databases could be used to check compliance in the EU but need to cover most buildings and be up-to-date.

A lack of resources and know-how within the responsible local authorities can limit the impact of the requirement. In the UK, the practical challenges in identifying non-compliant properties, contacting landlords, and resourcing the activity make it difficult for local authorities to enforce the MEES efficiently. The impact has been hampered by insufficient technical capacity (no database to identify non-compliant landlords and properties) and lack of financial resources (not able to cover the enforcement costs), which left some local authorities incapable of properly enforcing the minimum standard[25]. The evidence also suggests that this is easily solvable through financial support and capacity building programmes for the local (implementing) bodies.

The penalty of not complying ought to be high enough to discourage non-compliance. The penalty can be monetary, with a standard penalty or concerning the magnitude of the violation (i.e. kWh or CO_2 exceeding the minimum threshold), or operational, such as not being able to use the dwelling until it meets the standard.

Trigger points

A trigger point refers to a specific date or event, at which the building owner must comply with the defined requirement. The most common trigger point for compliance is a specific date by which the buildings must comply with the standard. Compliance can also be based on trigger points in a building's life cycle, as in the German Renewable Heating Obligation, in which the building owner ensure the renewable heating share exceeds 15% when the heating system is scheduled to be updated. Besides, the trigger point could link to complaints by tenants, as in Flanders, where the pointing out of inadequate indoor environment could force the landlord to carry out certain measures.

Awareness

Limited awareness and understanding of the required actions for compliance or about certain exemptions, can adversely influence the effectiveness of MMR. In England, 35% of the landlords with the lowest EPC labels (E, F and G) were "not at all aware" of the requirement[26]. One reason for the lack of awareness for MEES in the UK relates to insufficient communication and awareness-raising activities. This is partially the result of the large administrative burden.[27] To increase awareness the UK government has issued several guidance documents for landlords on complying with the minimum

[24] Sunderland et al. (2020). "Filling the policy gap: Minimum energy performance standards for European buildings". RAP. (Available: Online)
[25] RSM (2019) Enforcing the Enhancement of Energy Efficiency Regulations in the English Private Rented Sector. (Available: Online)
[26] BEIS (2020) Evaluation of the Domestic Private Rented Sector Minimum Energy Efficiency Standard Regulations. (Available: Online)
[27] Sayce, S & Marji Houssain, S. (2020). "Minimum Energy Efficiency Standards (MEES): one year on: A Progress Report". (Available: Online)

standard, thereby informing them of the requirements, funding options and the possible penalties, as well as providing examples.[28]

While the large real estate investors will be aware of an MMR, adapt their portfolio accordingly, the small private landlords might not.

In addition to extensive awareness-raising, regular sharing of best practices (e.g. what measures did my neighbour implement) and progress would incentivise compliance. Details on improvements made to various types of single-family buildings can be published digitally so potential new owners have ready access to information that will support planning future building renovations. This is part of a variety of complementary programmes (including technical and financial support) to motivate property owners to achieve the energy efficiency targets for the housing sector.[29] One-stop shops could be a good platform to communicate with property owners as well. Regional one-stop-shops are appearing throughout Europe to assist the regional decarbonisation effort, such as Oktave in Grand Est (France), SuperHomes in the Tipperary region (Ireland) and RenoWatt in Wallonia (Belgium).

Lead time

Most of the MMR offer lead times of 5-10 years to allow the building owners to plan for compliance, as well as signal to market actors the need to adapt. Thereby early impact can be facilitated, which can be further leveraged through financial incentives for early compliance. In the Netherlands, even though compliance will only be enforced by 2023, early notification of the programme has already set in motion a significant change in banks' lending behaviours and an increase in investment in the renovation and transformation of commercial properties.[30] The Dutch government has taken several measures to make this happen. They developed an online tool that enables building owners to explore investment costs, annual savings, payback times and CO_2 savings as guidance to meeting the office building performance standard currently in place. In addition to this, the Dutch government has certified energy advisors to assess and recommend improvements and has established a grant that covers the cost of this advice.

Financial support

Providing financial support and linking the requirement with existing funding mechanisms might be an additional motivator for property owners to comply with MMR. Furthermore, a comprehensive framework of public subsidies, financial incentives is fundamental for the successful and equitable implementation of an ambitious renovation strategy.[31] An illustrative case in France, where the national government has implemented a variety of loans, grants and refunds to help property owners achieve MMR in the Climate and Energy Law.[32] The UK initially also had financial support, with the pay-as-you-save finance initiative called Green Deal Finance. The government withdrew its support as part of the Green Deal abolishment.[33] In Boulder, Colorado, nearly US$1 million was invested in improving rented housing through rebates.

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[28] Guidance Website Domestic Private Rented Property (2017). Government of the United Kingdom. (Available: Online)
[29] Nadel, S & Hinge A (2020) Mandatory Building Performance Standards: A Key Policy for Achieving Climate Goals. ACEEE (Available: Online)
[30] Nadel, S & Hinge A (2020) Mandatory Building Performance Standards: A Key Policy for Achieving Climate Goals. ACEEE (Available: Online) & Sunderland et al. (2020). "Filling the policy gap: Minimum energy performance standards for European buildings". RAP. (Available: Online)
[31] Sunderland et al. (2020). "Filling the policy gap: Minimum energy performance standards for European buildings". RAP. (Available: Online)
[32] Nadel, S & Hinge A (2020) Mandatory Building Performance Standards: A Key Policy for Achieving Climate Goals. ACEEE (Available: Online)
[33] Ibid

Combined with technical assistance, this has led nearly all 23,000 licensed rental units to comply with the energy efficiency standard.[34]

Financial support can also be used to make the requirement more palatable for key stakeholders. The review of existing cases shows that the requirement is generally accompanied by financial support (grants, low-interest loans) and technical support (such as free energy advice).

- The MEES in England and Wales was one part of the Green Deal package, which also included free energy advice and the opportunity to pay for energy efficiency measures through savings on future energy bills (i.e. on-bill financing).
- The planed MMR in Scotland will be accompanied by financial and technical support for private homeowners. This includes free advice, interest-free loans, and extra subsidies for low-income households.[35]
- The Dutch MMR for office buildings is supported by technical assistance to help the owners to comply with the requirement. Additional support includes grants for energy advice, tax deductions for the renovation investment,, green investment allowances and green loans with preferential interest rates.[36]
- The French MMR, which sets a minimum standard at EPC E for all residential buildings, is accompanied by several support programmes, including the Energy Transition Tax Credit (CITE), interest-free eco-loans, the Better Living (Habiter Mieux) subsidy programme, the regional energy renovation platforms for technical assistance, and an Energy Renovation Guarantee Fund that provides government-backed loans to low-income households.[37]

Targeted building segments

The reviewed cases target different building typologies, based on their use or size. In the EU, the divide is typically between residential and non-residential buildings, with most implementing Member States have implemented, or are planning to implement, two versions of the MMR for the different typologies (see the UK, France, Flanders, Belgium). This binary approach can cause some uncertainty as many buildings incorporate both residential and non-residential dwellings. In the US, the size of the building in terms of floor area (or in terms of consumption?) (i.e. several MMR focus on "larger buildings") is the determining factor.

The analysis of the cases shows that there are many ways public authorities can implement and enforce MMR for existing buildings. A common objective of almost all cases is to mitigate the climate impact and reduce the energy need from the building sector. Most cases in the US target non-residential and larger building owners, while the focus is more evenly split in the EU between residential and non-residential buildings.

Appendix 1 includes additional information and case studies.

What do the stakeholders think?

The findings of this study have been guided by stakeholder input and feedback. 113 stakeholders answered the detailed questionnaire on MMR and its potential, while over 100 participants joined the online workshop. The stakeholders represent different sectors and professions, including building owner representatives, tenant organisations,

[34] Ibid
[35] Sunderland et al. (2020). "Filling the policy gap: Minimum energy performance standards for European buildings". RAP. (Available: Online)
[36] Nadel, S & Hinge A (2020) Mandatory Building Performance Standards: A Key Policy for Achieving Climate Goals. ACEEE (Available: Online)
[37] Ibid

installation manufacturers, construction sector, financial sector, public administration, (energy) service providers, civil society, and research institutes.

Three-quarters (74%,) of survey respondents say MMR should focus on the overall energy performance of the building, while more than half (53%) think MMR could be linked to certain building components. 50% say it should be linked to the building's overall climate performance (i.e. cap in GHG/m^2/year) and 44% think it should encompass whole-life carbon too. During the workshop, support was more expressed for carbon efficiency as an MMR parameter because this aligns better with long-term objectives and offers more freedom to end-users on how to fulfil the requirement.

The stakeholders think the MMR can best be applied to the worst-performing buildings, excluding heritage buildings. This will achieve the highest impact in the short term. Additionally, the building owners' ability to comply with the requirement should be considered. The most widespread view (57% of respondents) is that MMR should encompass all building typologies.

Most stakeholders want the MMR to include both progressive enforcement of milestones and various trigger points, something reaffirmed in the workshop discussion. In the multiple-choice question on when the MMR should come into effect, most participants say MMR enforcement based on progressive milestones (66%) and trigger points (55%) are the best solutions.

See more details in Appendix 2.

2. RESEARCH APPROACH

The central aim of this study is to identify plausible ways for the European Commission to introduce MMR for existing buildings in the EU. In order to identify the best possible options, the potential impact and feasibility of different options are assessed and discussed. **Figure 7** gives an overview of the steps in the analysis, which are detailed and explained in this chapter.

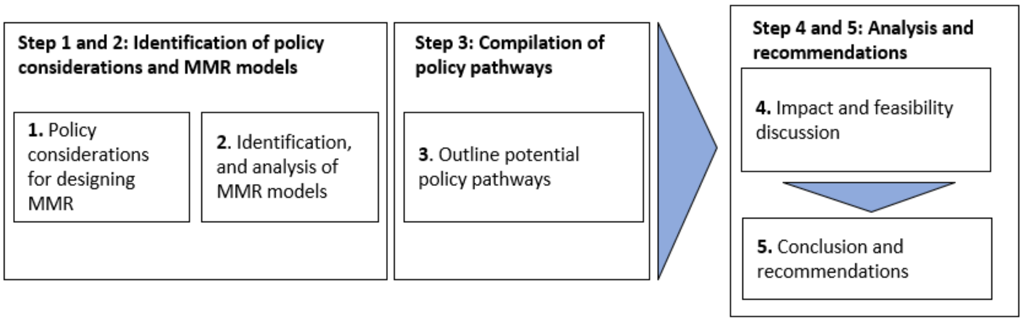


Figure 7: Research flow diagram

Step 1: Presentation of the most crucial policy considerations related to MMR for existing buildings, including the role in achieving 2050 target, interlinks with existing and future strategies, wider policy framework conditions, the vehicles for implementations, and various policy design features. The key aspects of each consideration are described, and the pros and cons are highlighted.

Step 2: Identification and presentation of the most suitable MMR models. The 'models' are archetypes of the most realistic ways MMR can be implemented, in terms of policy objective, metrics, targeted building segments and compliance mechanisms. The potential impacts and feasibility of these different models are discussed.

A qualitative impact and feasibility assessment are presented for each model, including:

- The **techno-economic** impacts are discussed based on the impacts of the model on the renovation rate, renovation depth, renovation quality and cost-optimality of the triggered renovations.
- The **socio-economic** impacts are discussed in terms of fairness, the split-incentive dilemma and access to housing.
- The impacts on **EU climate targets** are discussed based on the theoretical capacity of the model to contribute to EU climate targets for 2030 and the climate neutrality goal in 2050, whether the model integrates or supports renewable energy supply to buildings, and sustainability in terms of embodied carbon.
- The **feasibility assessment** looks at the practicability for a theoretical implementing body to introduce the specific MMR model, through the indicators of "ease of compliance", "simplicity" and "maturity of tools". The "ease of compliance" refers to how easy it would be to set up a compliance system for this MMR model and "simplicity" is how easy it is for the public body to explain (and end-users to understand), while the "maturity of tools" refers to the availability of existing instruments (e.g. EPC schemes) that can facilitate the implementation of the foreseen MMR model.

The impact and feasibility assessment are presented in radar charts (see an example in Figure 8). The score, based on evaluation of existing cases and expert views, indicates the potential of the models where 0 = poor, 1 = moderate, 2 = good and 3 = excellent. An in-depth analysis of the criteria is provided in an appendix.

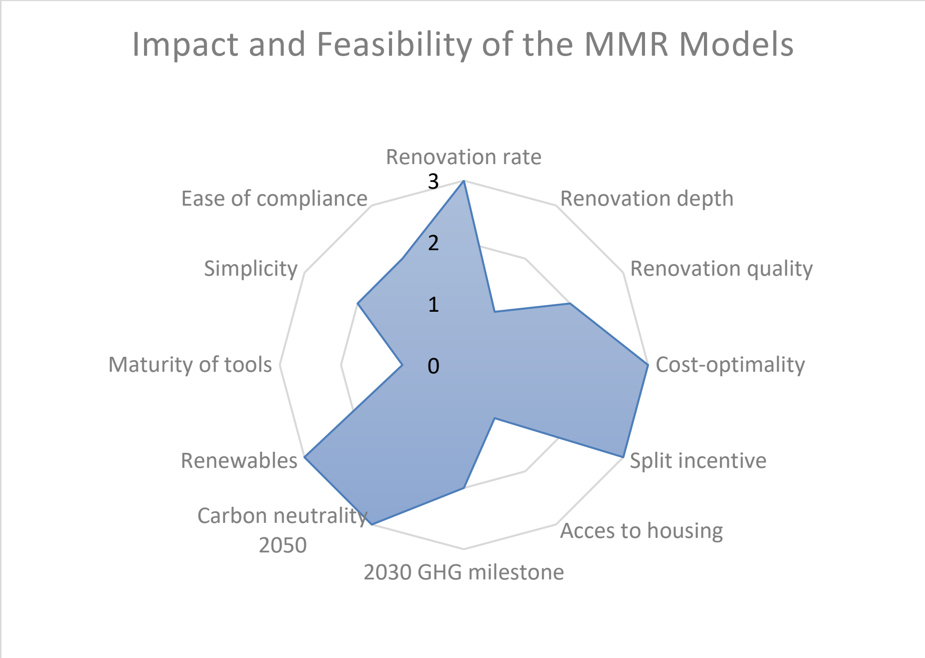


Figure 8: Example feasibility and impact assessment of MMR model

A quantitative impact assessment is also included to support the discussion of the main features of the MMR models (see example in Figure 9). The evolution of the final energy demand for heating and the related GHG emissions is modelled for each MMR model, considering the residential building stock of two Member States (France and Germany)[38], which were chosen because of the available data and the size of the countries. Assumptions are further detailed in the Appendix.

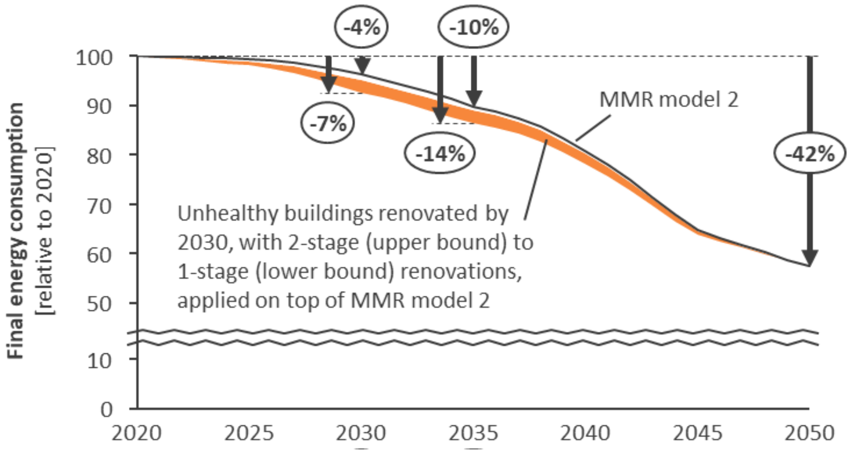


Figure 9: Exemplary quantitative impact assessment

Step 3: Based on the conclusions of Step 1 and Step 2, four policy pathways are developed showing four reasonable ways the EU can support the uptake of MMR for existing buildings. The pathways are illustrated through *timelines* (See Figure 10), exemplifying when an EU-wide MMR can become reality, how the EU can regulate or support an introduction of MMR, and what supportive measures are needed to achieve this.

[38] Given the data availability, it was not possible to perform the modelling on the complete EU building stock within the timeframe of the present study.

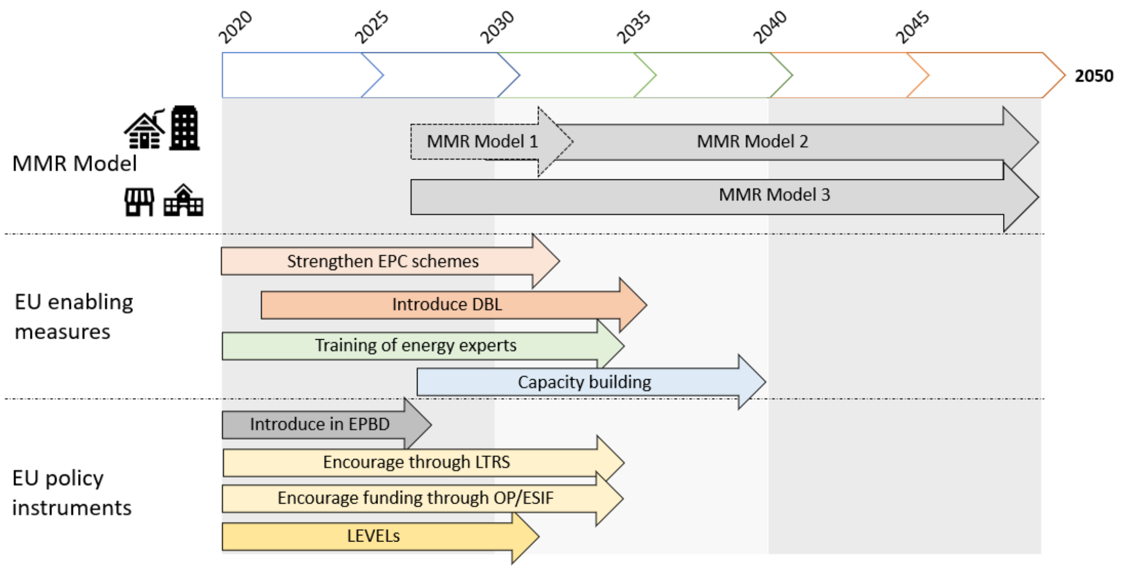


Figure 10: Illustrative policy pathway timeline

Step 4: The impact and feasibility assessment are performed throughout Step 2 and Step 3, and then summarised in Step 4. The impact and feasibility are first assessed for the MMR models, only taking into account the types of MMR. This analysis allows for a fair comparison between the different ways MMR can be implemented. The discussion on the policy pathways broadens the assessment to also include the policy process: when and how can it be introduced? what is the optimal combination of different models? and what supportive measures are needed?

Table 3 outlines the impact and feasibility parameters.

	Impact parameters	Feasibility parameters
MMR model	Renovation rate Renovation depth Renovation quality[39] Cost-optimality Split incentives Access to housing and affordability 2030 GHG milestone Carbon neutrality by 2050 Renewables	Applicability of existing policy instruments Simplicity Ease of compliance
	Impact parameters	Feasibility parameters
Policy pathways	Emission reductions (CO_2) Final energy consumption reduction (kWh)	Enabling measures Operationalisation based on timelines Subsidiarity, proportionality

Table 3. Impact and feasibility parameters

Step 5: Conclude the main lessons learned for the EU to consider.

[39] Refers to the reliability of the renovation measures and the extent to which the building performance improves as intended.

3. STEP 1: POLICY CONSIDERATIONS

This chapter outlines the main policy considerations around a European implementation of MMR for existing buildings. It shows that MMR is a flexible instrument that can be easily integrated into a wide range of existing and planned national policy contexts and can fit into the existing and planned EU climate and energy frameworks.

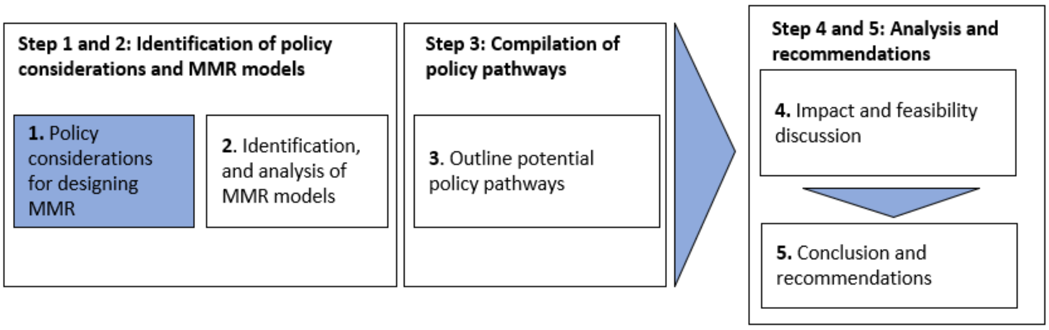


Figure 11: Research flow diagram - Step 1

The first section discusses how MMR can connect with existing and pending strategies, such as the Renovation Wave and the Circular Economy Action Plan. The second section describes the role of a wider policy framework for the efficiency of MMR, and especially financial support, skills in the value chain and awareness by all stakeholders. The third section discusses the role of EPCs, building renovation passports and digital building logbooks as an important ground for the implementation of MMR. The last section describes the key design options of MMRs, including metrics, building typology, compliance, and trigger points.

3.1. Contributing to the 2050 target

More than 220 million building units, representing 85% of the EU's building stock, were built before 2001. 85-95% of the buildings that exist today will still be standing in 2050. Decarbonising the building stock is a necessity for the EU to become a net-zero economy by 2050. To increase the rate and depth of building renovation to achieve this objective, policy needs to provide the right incentives, provide the needed framework conditions and remove barriers to renovations. The existing EU and national policies have shown to be insufficient[40]. This includes the existing MMR cases in Europe, which either has not yet been implemented or have not yet proven to be successful enough in triggering a large number of renovations[41] or has not been in implementation (yet or for long enough) to allow evaluation. Despite this, MMR for existing buildings stands out as one of the few policies that could achieve effective decarbonisation of the building stock.

The MMR can support the EU's decarbonisation effort by establishing the 2050 destination and by raising the lower bar.

- The MMR can be used to send a signal that anchor investors and business expectations, especially on the real estate market, clearly outlining what is required from the buildings. The requirement should already now declare what is the long-term objective for each building segment, or buildings types, by 2050 to allow the market to adapt. Some real estate investors would steer their investments towards future-proof buildings, i.e. the buildings complying with the

[40] See European Commission's assessment of National Energy & Climate Plans, which concludes "as far as energy efficiency is concerned, although the ambition level is higher than in the draft NECPs, the cumulative impact of the different NECPs still falls short of the existing energy efficiency target of 32.5%."
[41] See e.g. RSM (2019) Enforcing the Enhancement of Energy Efficiency Regulations in the English Private Rented Sector. (Available: Online)

2050 standards. The 2050 destination could also be aligned with green mortgages to further incentivise frontrunners.
- It would also act directly on renovating the worst-performing buildings. The requirement would effectively overturn many of the barriers to renovation and ensure that owners improve their buildings.

3.2. Relation to existing and new strategies

In the Renovation Wave strategy, the European Commission stated it will "propose mandatory minimum energy performance standards as part of the revision of the Energy Performance of Buildings Directive (EPBD) by the end of 2021". Beyond the EPBD, synergies can be made with other initiatives, including the New Industrial Strategy for Europe, the SME Strategy for a Sustainable and Digital Europe, as well as the Circular Economy Action Plan and disclosures relating to sustainable investments and sustainability risks.

The Renovation Wave strategy aims "to at least double the annual energy renovation rate of residential and non-residential buildings by 2030 and to foster deep energy renovations. Mobilising forces at all levels towards these goals will result in 35 million building units renovated by 2030." The strategy sets out measures to solve several key challenges, such as market failures (e.g. split incentives, the mismatch between financing needs and financial products offered), lack of expertise (e.g. insufficient workforce, lack of digital and green skills) and regulatory barriers (e.g. piecemeal and overlapping policies and laws, insufficient compliance with existing requirements).

MMR for existing buildings is a cornerstone in the Renovation Wave strategy and is also accompanied by a wider-policy framework, as being stressed in this study, including financial support, capacity building, a 2050 roadmap for whole life carbon reduction, Level(s), digital building logbook, and the building renovation passport.

The New Industrial Strategy for Europe[42] launched by the European Commission addresses the twin challenges of the green and the digital transformation of the EU's industry sector. It has been set out as one of the main enablers and accelerators for the European Green Deal. Its three key priorities are maintaining the European industry's global competitiveness and a level playing field; making Europe climate-neutral by 2050; and shaping Europe's digital future. One of the focal points of the EU Industrial Strategy is to address the sustainability of construction products and to improve the energy efficiency and environmental performance of built assets – in essence, striving for a more sustainable built environment.

This strategy could provide an important opportunity to link with the introduction of MMR. Small and medium-sized enterprises (SMEs) are essential in making MMR operational. The Renovation Wave also emphasises the role of SMEs and digitalisation and suggest several provisions to improve the European competitiveness through digitalisation, including "Horizon Europe, Digital Innovation Hubs and Testing and Experimentation Facilities". The European Commission's SME Strategy for a Sustainable and Digital Europe[43] will further support the further development of SMEs' role in the green and digital transition.

[42] Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions. A New Industrial Strategy for Europe, COM(2020) 102 final,
[43] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. An SME Strategy for a sustainable and digital Europe, COM(2020) 103 final.

Linked to this strategy is the Circular Economy Action Plan[44] adopted on 11 March 2020 by the European Commission. The Action Plan was announced the day after the EU Industrial Strategy was presented, to mobilise the industrial sector. The 'Communication on A New Circular Economy Action Plan' has identified construction and buildings as one of the key product value chains in which comprehensive and coordinated action is needed. Greater material efficiency could significantly reduce current GHG emissions from material extraction, manufacturing construction products, construction and renovation of buildings. The Strategy for a Sustainable Built Environment (planned for 2021) will ensure that action across several policy areas is coherent. It will promote circularity principles throughout the lifecycle of buildings, through e.g. addressing the sustainability performance of construction products in the context of the revision of the Construction Products Regulation, developing digital logbooks for buildings to monitor durability and adaptability, and using the Level(s) tool to integrate LCA in public procurement and the EU sustainable finance framework.

The Circular Economy Action Plan could provide strong means to achieve the targets set by MMR, such as minimum carbon efficiency requirements for existing buildings, by translating them into circular economy actions in some way. If linked to this Action Plan, the implementation of MMR could greatly benefit from the support provided by the European Commission in accelerating the transition to a circular economy, in terms of skills development, funds and other enabling measures.

The EU taxonomy framework published in 2020 establishes criteria for determining if economic activities qualify as environmentally sustainable.[45] The purpose of this regulation is to drive investments in sustainable alternatives. It states 'The renovation of existing buildings to improve their energy performance makes a substantial contribution to climate change mitigation by reducing energy consumption and GHG emissions for the remaining operational phase of the buildings, and by avoiding emissions that would be associated with the construction of new buildings.' It requires a first step to integrating life cycle thinking, by requiring reporting on whole-life carbon for large new buildings and including whole-life carbon benchmarks once developed. The taxonomy is important because it can drive investments toward the long-term goal of making buildings compliant with the 2050 target, while the MMR is elevating the bottom floor (i.e. the worst-performing buildings).

The regulation on disclosures relating to sustainable investments and sustainability risks could potentially be relevant for MMR as it requires financial market actors to disclose sustainability risks and impacts. Given that real estate has a long tenure and can make up a significant asset class in investment portfolios, the sustainability risks and impacts emerging from these investments will need to be assessed and disclosed according to the new regulation. As a consequence, financial market actors are expected to look much more closely at the activities they are financing and investing in. The need to disclose carbon-related risks and massive stranded assets will hardly make non-sustainable investments an attractive deal. This will further contribute to the accelerated value depreciation of assets that have not been improved as the market will increasingly recognise that inefficient buildings may start to present an economic and regulatory risk.

3.3. Wider policy framework

MMR introduction must be embedded in a wider policy framework, at the national level, to become successful. Each Member States will need to tailor its wider policy framework

[44] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A new Circular Economy Action Plan for a cleaner and more competitive Europe, COM(2020) 98 final.

[45] Regulation (EU) 2020/852 of the European Parliament and the Council. Establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088.

to support the introduction of MMR, as much of the success of the implementation depends on national factors and specificities (see the section on existing cases).

3.3.1. Financial support programmes

The European Commission estimates that to achieve the proposed 55% climate target by 2030, around EUR 275 billion of additional investments are needed per year[46]. The Renovation Wave is included in the European Green Deal, which together with the EU recovery plan unveil new funding opportunities for the renovation of the least efficient building stock. The upcoming long-term budget (2021-2027) can also be used to steer funds for this building renovation.

The Recovery and Resilience Facility, which is currently under negotiation and which the European Council agreed to endow with EUR 672.5 billion, 37% of which would be targeted to climate-related expenditure, can support renovation investment and energy and resource efficiency-related reforms across the Member States.

The Renovation Wave strategy outlines several provisions for "reinforced, accessible and more targeted funding", which can directly or indirectly, support the introduction of MMR:

- The cohesion policy funds will remain the main source of EU public funding, from which millions of EUR are directed towards energy efficiency of the building stock. The Member States channel and directs these funds through Operational programmes, which could be used to support the objectives of an MMR. The Renovation Wave suggest that the programme objectives are derived from the national NECP and LTRS.
- InvestEU will act as a single EU-level investment support programme to provide technical assistance and financing backed by an EU budget guarantee to unlock private investments. The programme can enable energy service companies to offer energy performance contracting solutions, possibly enabling building owners to renovation beyond the minimum standard, with a small or no upfront cost. The programme is also available to support life cycle performance.
- The strategy document also concludes that "the Commission stands ready to advise Member States that are considering using revenues from the EU Emissions Trading System (ETS) and funding opportunities under the ETS Modernisation Fund as a source of funding for building renovation programmes, in particular for lower-income households." Czechia is currently using its ETS surplus to offer energy renovation subsidies through the New Green Savings Programme. Similar programmes could be used to support renovations linked to MMR.
- "Existing energy efficiency obligation schemes under Article 7 of the Energy Efficiency Directive can be effectively used for all types of buildings to engage new intermediaries like utilities, deliver technical expertise and offer aggregated services to reduce transaction and administrative costs". Several existing one-stop-shops are directly (e.g. ProEnergy Homes in Ireland) or indirectly (e.g. Heero in France) utilising the obligation to offer attractive renovation offers.
- "A renovation wave can also be an opportunity to spur the development of green loan and mortgage financing. An upgraded system of EPCs demonstrating efficiency gains will allow banks and other financial institutions to offer credit and mortgage financing to green their portfolios and to pool buildings as collateral for the issuance of covered bonds". On the same note, "the Commission is developing the EU Taxonomy, with technical screening criteria for the buildings sector, to direct private capital towards sustainable investments in

[46] See "Identifying Europe's recovery needs", SWD(2020) 98 final and "Stepping up Europe's 2030 climate ambition Investing in a climate-neutral future for the benefit of our people", SWD(2020) 176 final.

energy and resource renovation, relying on EPC and nearly zero-energy building standards". Energy efficiency mortgages and green loans could encourage building owners to implement additional renovation measures than what the minimum standards would require. Many benefits can be attained if both systems are linked to the EPC schemes.

The current EPBD requires national governments to establish LTRS for mobilising investment in the renovation of the national stock of residential and commercial buildings, both public and private. All Member States had to provide their new LTRS to the European Commission by 10 March 2020. As a crucial part of the LTRS, Member States must support the mobilisation of investments into the renovation levels required to achieve the goals set by the directive. The LTRS should be used to holistically plan the renovation of the building stock, which could include a mix of MMR for existing buildings and targeted financial support.

BPIE's analysis of the LTRS shows that the Member States did not follow the structure of Article 2a or the Commission's guidance when it comes to "mobilisation of investments", which comprises five specific dimensions: most cases Member States did not present their financial measures according to these dimensions. The analysis also concludes that "while Member States generally provided reasonable details on their renovation policies (existing or proposed), few explicitly geared these towards achieving deep renovation". [47]

While financial support is needed for all concerned building owners, special attention should be put on two groups:

- Groups vulnerable to energy poverty: A considerable share of the worst-performing building stock is owned/rented by people who are vulnerable to a cost increase. The financial support programmes should reduce the possible negative effect of MMR on this group.
- Real estate investors and owners considering deep renovations and/or early compliance: Building owners and investors should be incentivised to go beyond the minimum requirements, as defined by the MMR. This can be achieved through premiums for one-stage deep renovations that directly meet the long-term requirements, which can be specified in the EU taxonomy or certain climate/green bonds[48]. As with MMR requirements, the trick with climate bonds is that the threshold is gradually tightened, so the issuer of the bond needs to continuously demonstrate that the underlying asset pool meets the new climate criteria.

3.3.2. Skills in the construction value chain

One of the main challenges for driving transformational change within the construction sector is the transition and consolidation of the workforce.[49] A well-equipped and trained workforce is required to realise the building decarbonisation objectives, as set out in the EPBD and the Renovation Wave. For example, new techniques like industrial prefabrication, building information modelling (BIM), and industrial 3D printing are innovations that require different skills from traditional construction works. Similarly, different skills are required to guide a building owner towards a net-zero energy/carbon renovation than issuing an EPC. The transition to climate-neutral building stock will also demand an increase in green and circular skills. Building sector federations should play

[47] BPIE (2020) A review of EU Member States' 2020 Long-Term Renovation Strategies. (Available: Online)
[48] Climate or green bonds raise funds for climate oriented projects, including investments in renewables and energy efficiency in buildings. Aligning the specifications of these bonds with EU's long-term climate objective, would funnel investments towards this objective.
49 BPIE & I2-4C (2016). "Driving Transformational Change in the Construction Value Chain". (Available: Online)

a defining role in this, besides stimulus and education programmes from public authorities.

The European Construction Sector Observatory also acknowledges that the availability of higher- and lower-skilled workforce is amongst the most significant obstacles for the future development of the building sector.[50] In a changing construction sector, the transformation of the existing workforce through the acquisition of new skills is essential.

3.3.3. Public awareness and a simple renovation journey

Public awareness, understanding and acceptance of MMR are key for effective implementation. People should be aware of the requirement itself as well as the purpose behind it. Lessons learned from a couple of the existing cases show that it is difficult to get the right information out there. Authorities at all governance levels (EU, national, regional and local) should, therefore:

- Deliver communication campaigns targeted at the building owners that will be affected by the requirement. The information must be easy to grasp when explaining the reasons behind the requirements and the associated benefits, as well as when and how to comply, including links to energy experts, one-stop-shops or financial support programmes.
- Continue to support the development of one-stop-shops, and other renovation services, to simplify the process of complying with MMR. One-stop-shops, public and private models alike, are market-driven and will adapt their services to MMR.

3.4. MMR needs a facilitating infrastructure

The policy infrastructure in which MMR will be launched needs to be able to carry the requirement. This section discusses the role of three central instruments, which can facilitate better implementation of an EU MMR framework:

- EPCs, which are the most obvious benchmark for MMR, indicate the performance level of a building.
- Building renovation passports, which set out a staged renovation roadmap for an individual building and thus help the building owners to avoid technical and economic lock-ins
- Digital building logbooks, a digital repository for all building-related data, which can allow public authorities to monitor the progress and enable recycling of materials.

3.4.1. Energy performance certificates

All EU Member States have now implemented national EPC regimes. Different implementation approaches have led to a diverse set of instruments, varying in terms of scope and available information, resulting in some cases in limited reliability, compliance, market penetration, availability and acceptance.

The most important feature of MMR for existing buildings is that they are comparable and based on reliable calculation methodologies. EPCs have struggled with reliability and comparability since their introduction. When two identical buildings receive different EPC ratings, due to inconsistencies in the EPC methodology, poorly qualified EPC

[50] ECSO. (2020). "Analytical report. Improving the human capital basis". European Construction Sector Observatory. (Available: Online)

issuers, or something else[51], it hampers the instrument's impact and people's trust in them.

EPCs themselves have not been effective in driving renovations. Cost and time constraints often result in EPCs containing poorly-tailored recommendations. Evidence suggests that an onsite visit, including the chance for the user to interact with the expert, influences the perceived quality and reliability of the recommendations and the chance that they will be implemented.[52] The EPC can also be integrated with the building renovation passport.

The Renovation Wave strategy envisages the EPC schemes to be the enabling vehicle for implementation of an MMR. It also recommends several provisions to improve the existing EPC schemes, focusing on their reliability, market penetration and availability. The strategy proposes to "introduce a stronger obligation to have EPC alongside a phased introduction of mandatory minimum energy performance standards for existing buildings". Furthermore, it notes that "the Commission considers that EPC and their availability in databases improve the transparency of the performance of the building stock. At the building level, EPCs inform about energy performance, the share of renewables and energy costs. At district, regional, national or Union level, they are crucial for identifying the worst-performing buildings in urgent need of renovation."

Metrics

The existing EPC ratings are, in most Member States, difficult for building owners to fully grasp. EPC methodologies tend to be complex and rarely properly explained, making it difficult for the building owner to understand how different measures will influence their rating.

EPCs have been developed to display the energy performance rating of a building, typically in annual primary energy use (i.e. kWh/m²/year). Among the 27 EU Member States, 12 have adopted the methodology exclusively based on asset rating (theoretical energy use), while the other countries integrate both the asset rating and measure energy use, in various calculation methodologies. Several Member States apply both the asset and measured energy, which makes comparability between different EPC labels, with different methodologies, difficult. While EPC methodologies still differ across the EU, the amended EPBD [2018/844/EU] requires Member States to 'describe their national calculation methodology following the national annexes of the overarching standards' set out in the ISO 52000 series, which could be the first step towards harmonisation of methodologies.

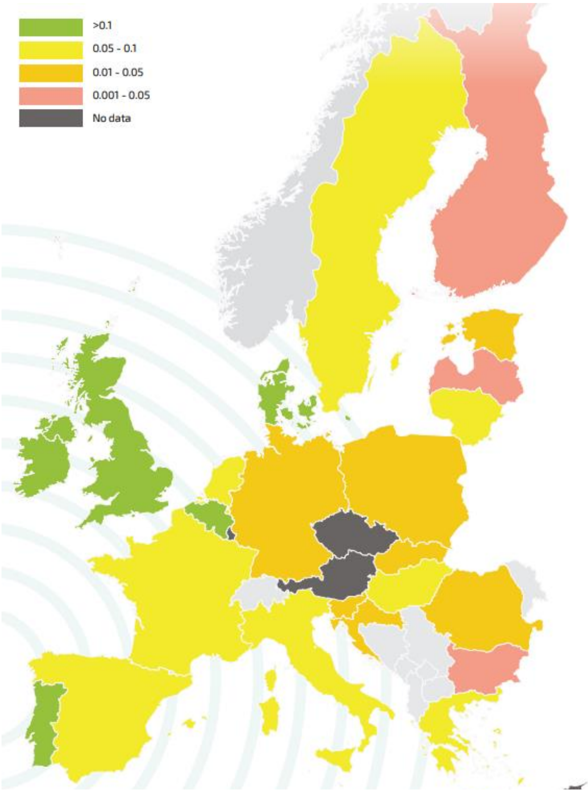


Figure 12: Total number of registered EPCs per capita. (Source: X-tendo based on EPC numbers from EPBD CA Key Implementation Decisions and information provided by X-tendo partners. 2018 population number from Eurostat. Map design: Showeet.

51 See work by the Qualicheck project. (Available: Website)
52 X-tendo (2020) Energy Performance Certificates – Assessing their status and potential. European Commission – Horizon 2020 project. (Available: Online)

Market penetration

The effectiveness of the MMR implementation relies on a universal introduction of EPC, as the ratings are used to check compliance.

The Horizon 2020 project X-tendo conducted a compilation of how many registered EPCs each country had in its database. Figure 12 shows the number of registered EPCs per capita, which reveals that only the UK, Ireland, Portugal, Denmark and Belgium have more than one EPC registered per 10 inhabitants. England and Wales, where the highest frequency of EPCs is found, have about one EPC per five dwellings – meaning that even here, the large majority of buildings are still without an EPC. This is seen as a major barrier hampering the potential impact.

If just a fraction of targeted buildings has an EPC, it will make an MMR impossible to function effectively. Policymakers can reduce this problem by making sure that all targeted buildings have an EPC a couple of years before the MMR threshold comes into place.

Quality and reliability

Maybe the most important prerequisite for MMR, after the availability of EPCs, is the reliability and quality control of the EPC rating, as it is foreseen to be the MMR threshold. The reliability of EPCs remains the subject of scrutiny and leaves room for improvement[53]. When EPCs were first introduced in the EPBD in 2010, quality control and reliability were not addressed sufficiently.[54] To achieve energy performance objectives, the 2018 revision of the EPBD stated that 'the transparency of energy performance certificates should be improved by ensuring that all necessary parameters for calculations, both for certification and minimum energy performance requirements, are set out and applied consistently.'[55] The technical annex of the EU taxonomy regulation also highlights the absence of comparable building stock data for benchmarking, which EPCs could provide, as a challenge for the development of climate mitigation criteria for the built environment.[56] The Renovation Wave strategy also emphasises this potential role of the EPC.

The reliability of EPCs depends on various factors including the methodology, independent quality control, the qualification and accreditation of certifiers, and the compliance system. Balancing these factors while assuring affordability of EPCs remains a challenging task, which Member States try to address in different ways.[57] Following the EPBD legislation, all countries perform random quality checks of the EPC input. How this quality assurance is conducted differs between the Member States. Data inaccuracies can be caused by lack of competence of the EPC expert, procedures not being properly followed, incorrect on-site measurements or wrong pre-calculated values in the methodology.[58]

The implementation of effective systems of quality assurance is a challenging task. It needs to be considered at every stage of the certification process, including training and control of auditors, quality checks in the software, and verification of the certificates issued. At the same time, the cost of the system should be balanced to avoid a

[53] For example, Wales announced on 30 September 2020 that the success of a strategy to combat energy poverty will be measured in reduction of kWh instead of impact on EPC rating. (Available: Website)
[54] X-tendo (2020) Energy Performance Certificates – Assessing their status and potential. European Commission – Horizon 2020 project. (Available: Online)
[55] Directive (EU) 2018/844 of the European Parliament and Council. Amending the energy performance of buildings Directive.
[56] EU Technical Expert Group on Sustainable Finance (2020). "Technical annex to the TEG final report on the EU taxonomy". (Available: Online)
[57] X-tendo (2020) Energy Performance Certificates – Assessing their status and potential. European Commission – Horizon 2020 project. (Available: Online)
[58] Ibid

significant increase. Increasing trust and establishing a good reputation for EPCs among building owners, potential tenants and other market actors is a challenge that still needs to be improved.

3.4.2. Building renovation passport

Deep renovation is a complex process that involves a complete overhaul of the energy performance of a building. Most people are aware that better insulation of walls, roofs and basements will lower the energy consumption of the household. However, many people are not aware of the issue of air leakages[59], allowing heat to escape the building through weak points in the building envelope. Achieving a successful deep renovation requires expertise and careful detailing of the renovation measures, especially when a deep renovation is achieved in several stages. The building renovation passport (BRP) can facilitate this by providing a tailored renovation roadmap for a specific building, which can be carried out in one stage or multiple steps over several years.[60]

A BRP can be seen as an evolution of the EPC, as it supports building owners with tailored renovation advice. This results from an on-site energy audit fulfilling specific quality criteria and indicators established in dialogue with the owner. The BRP presents a staged renovation plan, outlining the roadmap to a low-carbon building. It is not just a technical intervention, as it integrates the occupant's needs and specific situation (e.g. age, financial situation, the composition of the household, etc.) and outlines each step and links proposed measures.

A feasibility study of the possible introduction of optional BRPs concluded that 'existing Building Renovation Passports have proven that the instrument is effective in providing renovation advice taking into account the long-term vision for the building stock. It influences the renovation rate (number of energy renovations), renovation depth (magnitude of the renovations), the timing of the works (people with a BRP tend to renovate earlier than they previously planned) and the quality of the works (fewer mistakes and unwise renovation decisions).'[61]

As the BRP sets out tailored renovation advice based on an energy audit, it could also integrate an LCA to also incorporate whole-life carbon emissions.

3.4.3. Digital building logbook

A digital building logbook (DBL) is a digital repository for all building-related data on individual buildings, which facilitates information sharing within the construction sector, and between building owners and tenants, financial institutions and public authorities. The digital building logbook should include all building-related data, such as 'administrative documents, plans, description of the land, the building and its surrounding, technical systems, traceability and characteristics of construction materials, performance data such as operational energy use, indoor environmental quality, smart building potential and lifecycle emissions'[62].

The DBL is instrumental to gain a better overview of the building stock at all levels. At the same time as it is an enabler of circularity for the construction sector and the built environment, it allows to better assess the effectiveness of energy efficiency measures on a larger scale. It can tailor support measures, set benchmarks and strategies, monitor progress towards climate goals. Comprehensive information about buildings

[59] Leakages often occur through junctions between walls and other walls and between walls and windows
[60] Fabbri, M et al. (2020). "Final report – Technical study on the possible introduction of optional building renovation passports". European Commission. (Available: Online)
[61] Ibid
[62] Volt, J & Toth, Z (2020). "Definition of the Digital Building Logbook". European Commission. (Available: Online)

means that DBL users and value chain actors can make better decisions about how and when to renovate buildings.

The introduction of a Digital Building Logbook can support the MMR in several ways, including:

- Logging each material used in the construction/renovation of buildings in the digital building logbook, including the exact location, allows for recycling and traceability of chemicals.
- Tracking performance along the life cycle. Improving the overall transparency, trust and collaboration among different stakeholders.
- It enables public authorities to monitor the progress towards decarbonisation and to better tailor requirements for certain building typologies.
- Availability of granular performance and maintenance data in addition to the EPC and smart readiness indicator could provide a more robust and reliable indication of energy performance and reduce performance gaps.

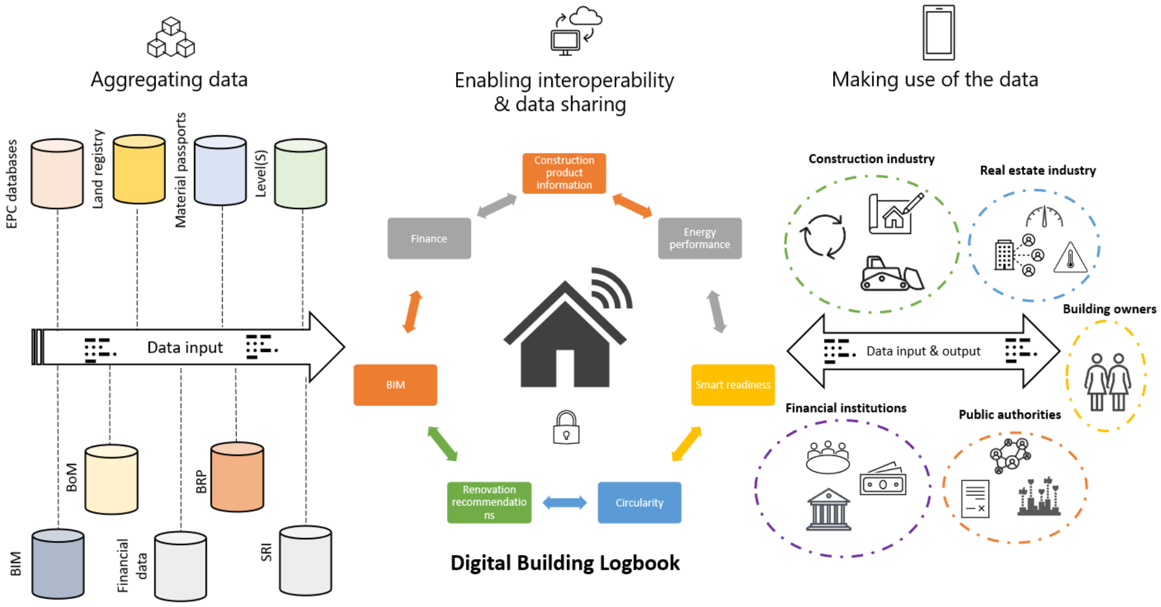


Figure 14: Role of the Digital Building Logbook (Source: BPIE)

The Renovation Wave strategy declares that "the Commission will introduce Digital Building Logbooks that will integrate all building-related data provided by the upcoming Building Renovation Passports, Smart Readiness Indicators, Level(s) and EPCs to ensure compatibility and integration of data throughout the renovation journey."

3.5. MMR is a flexible instrument thanks to a diversity of design options

The design options consist of the main aspects of how MMR can be implemented in practice, including the metrics, building typology, compliance and trigger points.

3.5.1. Metrics

A well-designed metric – tailored to the specific purpose of the MMR – is crucial for its success. A metric serves to express the performance of a building in a specific category, for example, an energy metric in kWh or a carbon metric in CO_2. For the building sector, metrics are mainly used to evaluate the energy performance of the building, its climate impact, or indoor environmental quality.[63]

Metrics are used for national policy targets for emission reductions, but also for determining the emission reductions of a renovation. Whereas the former is often expressed as a reduction in tonnes of CO_2 at a specific time, there are many different ways in which the performance of a renovation could be expressed. For example, one could assess the efficiency of heating, ventilation and air conditioning (HVAC) installations, the thickness of windows or even the embodied emissions of construction materials. These metrics can be applied for a whole country or one single building or measure. For whole countries, these are often expressed in terms of tonnes of carbon equivalent. For single buildings, however, metrics can get more specific and relate to construction materials, installations, or building elements.

Another important metric differentiation is between *asset-based* ratings and *measured-based* ratings:

- Asset-based ratings refer to a calculated energy efficiency level, which often aggregates the designed performance of the different building components (heating system efficiency, the thermal resistance of the envelope etc.). Most EPCs are fully, or predominantly, based on asset ratings. The main strengths are that it allows for a more reliable comparison between buildings, as the buildings with the same components should get the same rating. The main weakness is that the calculated energy performance is usually not aligned with the actual energy performance (i.e. the energy performance gap), due to the calculation, installation and/or user behaviour.[64]
- Measured-based ratings[65] include metrics based on actual energy consumption, which can be done through utility bills or smart meter data. A prominent example of an operational rating is the Energy Start Score in the USA, which is based on smart meter data.

Whole-life carbon metric

Embodied carbon is carbon emissions associated with materials and construction processes throughout the whole lifecycle of a building[66].

A low carbon transformation of the supply chain has the potential to decrease the embodied carbon emission intensity by around 75%.[67] This potential could be fostered by appropriate design of MMR, integrating whole-life carbon considerations based on reliable data, calculations and standards, which needs to be further evolved and operationalised before they effectively can underpin an MMR.

Besides the reduction of GHG emissions related to the energy used to heat and cool the building, the embodied carbon emissions of a deep energy renovation project amount to around 312kgCO_2e/m² for a normal single-family building.[68] Considering a 3% renovation a year of the European residential building stock, this would correspond to about 100Mt$CO_{2\text{-eq}}$ of annual embodied emissions.

[63] Fawcett & Topouzi. (2020). "Residential retrofit in the climate emergency: the role of metrics". Buildings and Cities. (Available: Online).
[64] IEA (2019) EBC Annex 71. Building Energy Performance Assessment Based on In-situ Measurements. (Available: Website)
[65] Also referred to as "operational rating"
[66] World Green Building Council (2019) Bringing Embodied Carbon Upfront. (Available: Online)
[67] Own analysis based on EU Calc data
[68] Röck et al. (2020). 'Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation'. Applied Energy. (Available: Online)

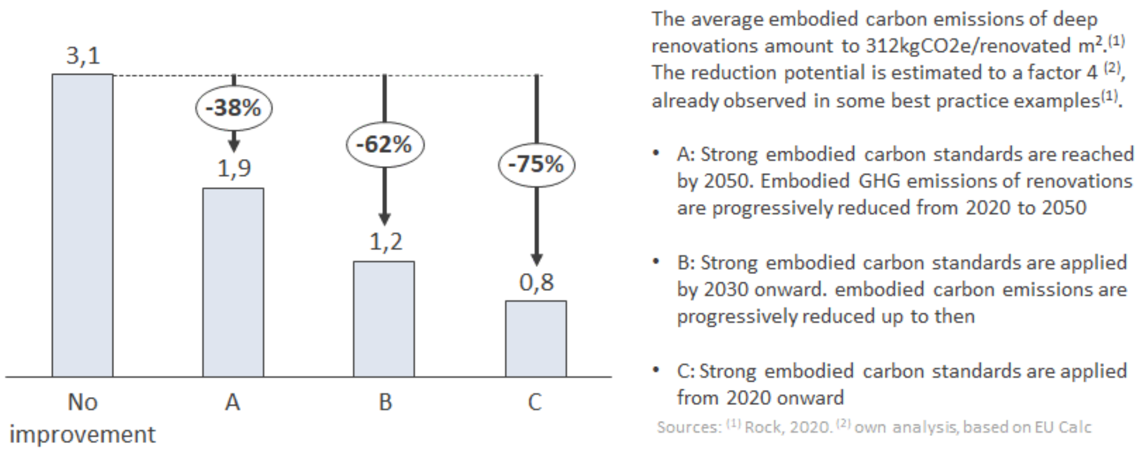


Figure 15: Accumulated 2020-2050 embedded GHG emissions corresponding to the deep renovation of 90% of the 25,000 million m² of European residential buildings [in GtCO2e].

MMR considering whole-life carbon emissions will help to limit the shift of GHG emissions from the energy used to heat buildings (i.e. operational energy) to upstream emissions in the value chain and potentially foster a low-carbon transformation of the value chain.

3.5.2. Building typology

MMR is often designed to target specific building segments. The design can be tailored to a building typology, specified to e.g. detached houses, terrace houses or apartment buildings. The building's function can also be a criterion for the design of MMR, e.g. residential or non-residential buildings. Another possible option is to target a specific segment of the housing market, e.g. privately owned, the rental sector or social housing, or e.g. buildings constructed before a given year. Furthermore, a common criterion used in certain jurisdictions is a minimum building (portfolio) size in terms of floor area in square metres.

The age of existing buildings in the total stock is a good indicator of the average efficiency of the building stock. The higher the share of new dwellings, i.e. built with more efficient standards, the higher the energy performance of the stock. In most EU countries, half of the residential stock was built before 1970 (i.e. before the first thermal regulations)[69].

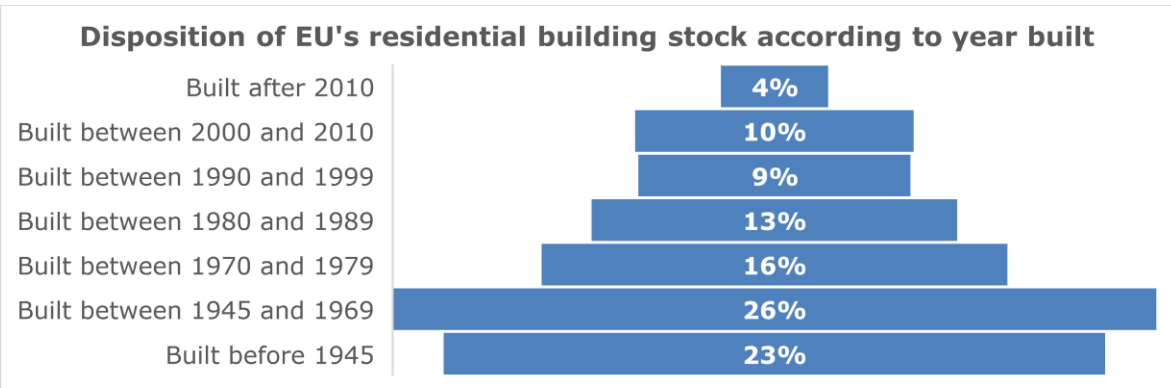


Figure 16: European residential building stock according to year built

[69] EU Building Stock Observatory. (Available: Website)

In the European Union, there are approximately 215 million residential buildings and 46 million non-residential buildings.[70] From the residential buildings, around 65% were constructed before 1980. Moreover, roughly 140 million dwellings are part of multi-family buildings. Non-residential buildings (e.g. education, healthcare, hotels and restaurants, public offices, private offices, trade and wholesale) account for 24% of the total floor area.[71] To achieve a significant impact, MMR might target with priority older residential buildings which have lower energy performance. Larger multi-family buildings and non-residential buildings are also relevant as target building segments.

Figure 17 shows that the residential sector is responsible for almost 75% of the EU's building stock's heating energy demand, in which single-family and terraced houses are most demanding.

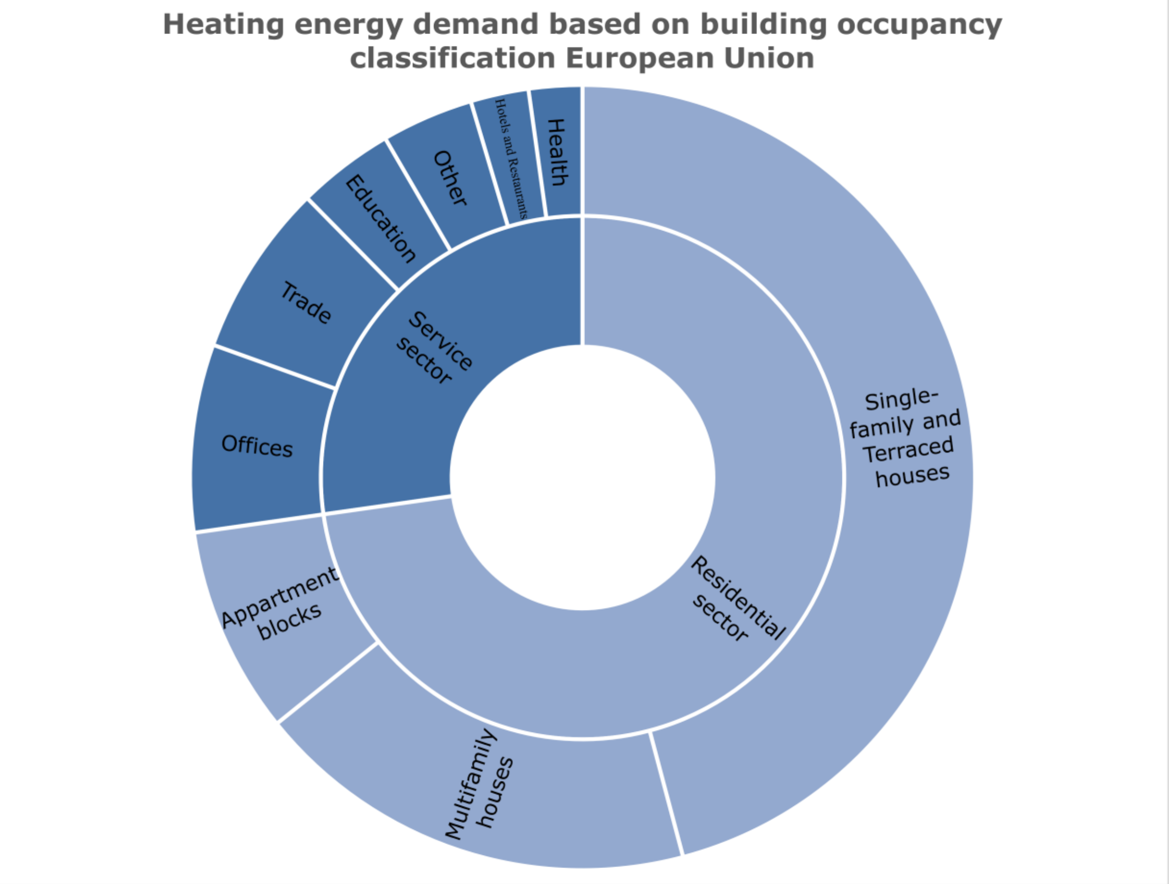


Figure 17: Heating energy demand - building use. Apartment blocks are multi-family buildings with five or more dwellings. Source: Hotmaps database

In multiple-ownership apartment buildings in most Member States, deep renovation decisions lie with homeowner associations.[72] MMR focused on triggering renovation at property transfer may not be as effective in multi-ownership buildings compared to single-ownership ones. The complex decision-making process in multi-ownership buildings maybe a considerable barrier to deep renovations. Mandatory implementation of renovation steps according to a BRP would demand action from homeowners associations (which need to have a clearly defined legal status and rely on agile decision

[70] EU Building Stock Observatory. (Available: Website)
[71] Entranze Project. Policies to Enforce the Transition to Nearly Zero Energy Buildings in the EU. European Commission - Intelligent Energy Europe programme. (Available: Website)
[72] The purpose, governance and frequency of homeowner association varies across the EU and well-functioning homeowners associations is not a given. See for example: Economidou M et al (2018) Energy efficiency upgrades in multi-owner residential buildings - Review of governance and legal issues in 7 EU Member States, European Commission JRC. (Available: Online)

procedures), where existing and new owners are aware of the upcoming requirement and can plan and budget accordingly. The defined renovation steps in the BRP could alleviate ambiguities and disagreements of which measures to invest in.

Finally, heritage buildings bring specific values and challenges, discussed in the European Framework for Action on Cultural Heritage.[73] The cultural and aesthetic value of these buildings can make them more challenging to renovate. For example, alterations of the facades or roof might not be possible without negatively affecting the outside appearance. Furthermore, these older buildings are often extra vulnerable to the effects of climate change.[74] As such, the applicability of MMR to heritage buildings should be tailored at the national or local level, where policymakers have the most knowledge on the local climate conditions and the cultural significance and sensitivities. A tailored renovation tool, like the BRP, could define the renovation stages to a target that is reasonable for these buildings.

3.5.3. Compliance

The existing MMR cases emphasise the need for effective communication channels between different organisations and authorities. The national/federal authorities are likely to regulate MMR and have overarching responsibility, while local authorities will be responsible for the groundwork, including informing citizens, checking compliance, collecting data and issuing penalties. Monitoring and evaluation are essential to ensure that energy performance is achieved. Good monitoring simultaneously facilitates compliance checks by providing regulators with insight into the energy performance of existing buildings. Sufficient administrative capacity is a pre-requisite to achieve qualitative monitoring and effective compliance.

In many existing cases, compliance is stimulated and enforced [carrot and stick] with on the one hand financial subsidies and grants, combined with financial penalties in case of non-compliance. The fine can increase depending on the duration of non-compliance and can be embedded in a bonus-malus scheme. These funds can be used for grants stimulating building owners to reach the 2050 target (i.e. deep renovation) as early as possible. Financial support programmes are often introduced alongside MMR to improve compliance and foster early action.

Furthermore, most jurisdictions have set up educational programmes for technical assistance. A barrier to enforcement in England and Wales was the lack of administrative capacity in the municipalities to carry out the enforcement and follow-up work. This illustrates the importance of well-equipped and trained local administrations and practical design for the effectiveness of MMR.

3.5.4. Trigger points

In the lifetime of a building, certain events lend themselves well to trigger a renovation. For instance, when a house is sold this provides an opportunity to renovate at the time when the new owners structure long-term financing (mortgage) and before they move in, thereby reducing the nuisance of the construction work. Additionally, a switch of tenants or a change of function of a building (section) can function as a suitable moment to renovate with least inconvenience for the building owners and users. MMR can target these 'trigger points' by requiring building owners to improve building performance. In the Flanders Energy Plan Draft, for example, non-residential building owners are required to renovate their building within five years of purchase.[75]. Other trigger points

[73] European Framework for Action on Cultural Heritage. (2018). European Union. (Available: Online)
[74] Historic Environment Scotland. (2020). "Climate Action Plan 2020-25". (Available: Online)
[75] Flanders Government (2018). "Ontwerp Vlaams Energieplan". (in Eng: Flemish Energy Plan). (Available: Website)

relate to regular maintenance works or personal circumstances of the inhabitants, such as a newborn family member or retirement.

The research institute CE Delft indicates in a report on zero-carbon buildings that utilizing trigger points for building renovation can contribute significantly to achieve a zero-carbon building stock in 2050[76]. Moreover, research from the Energy Saving Trust indicates that the majority of British building owners are willing to invest additional funds in energy efficiency measures when during already planned renovation measures[77]. This illustrates the relevance of harnessing the power of trigger points to improve building performance, and the potential the European Commission can tap into by integrating trigger points in the MMR design.

Figure 18 illustrates that the required renovation rate and depth can be reached with different means. 'If the energy demand of dwellings can be reduced by an average of 60% when changing owners (representing 1.7% of the dwellings per year), renovation associated with other key moments would not need to happen at as high a renovation depth.'[78] The activation of renovation requirements can be based on a country-specific analysis of the impacts and potential of different trigger points.

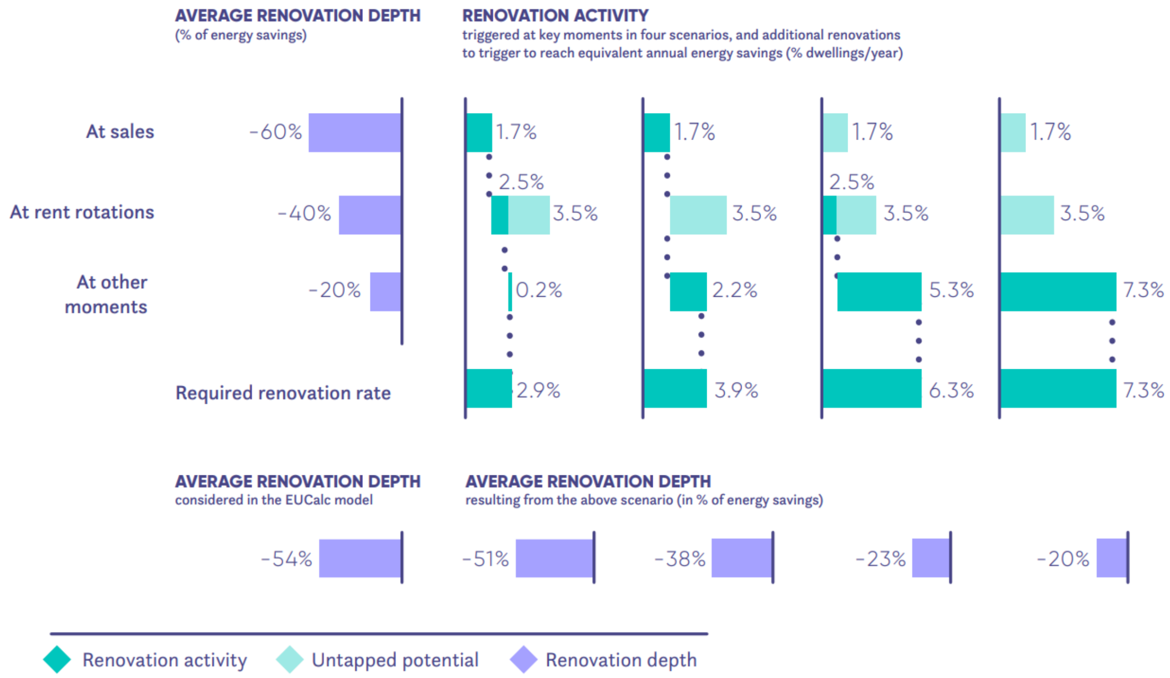


Figure 18: Different renovation rates and depths at key moments reach different average energy savings in four scenarios. The renovation depth is associated with three key moments (left-hand purple bars) and four scenarios (right-hand green bars) illustrate the required increase in the renovation rate resulting from lowered renovation depth following the untapped potential of key moments. The first scenario captures the full potential of key moments, leading to a 2.9%/year renovation rate with 51% average energy savings. Staged renovations outside of key moments would require a 7.3%/year renovation rate to provide similar energy savings. The bottom purple bars provide the average renovation depth corresponding to each scenario. Source: Kruit et al. (2020) Bringing buildings on track to reach zero-carbon by 2050

[76] European Climate Foundation. (2020). "Zero Carbon Buildings 2050". Modelling by Climact based on EU Calc data. (Available: Online)
[77] Energy Saving Trust. (2011). "A convenient truth – Promoting energy efficiency in the home". (Available: Online)
[78] European Climate Foundation. (2020). "Zero Carbon Buildings 2050". Modelling by Climact based on EU Calc data. (Available: Online)

3.5.5. Enforcement calendars

MMR could also be based on an enforcement calendar, which sets out a timeline for the affected buildings, defining when they need to comply with the specific requirements. Most commonly, and as implemented in the MEES in the UK, MMR increases the level of ambition over time, guiding the market towards a long-term target. In each enforcement step certain requirements are enacted, e.g. an EPC rating, specified carbon emission level, or something else.

Error! Reference source not found.19**Error! Reference source not found.** is a th eoretical exercise to show how an enforcement calendar works. It has been created by Climact for the Flemish Energy Agency and their work on the LTRS for Flanders.[79] This example illustrates that by 2030, all buildings with an EPC label F have been renovated (or demolished), while by 2035 all buildings with label E have been upgraded, etc. By 2050 all buildings have reached an EPC A label (or the best possible scenario for that building given technical and/or financial limitations).

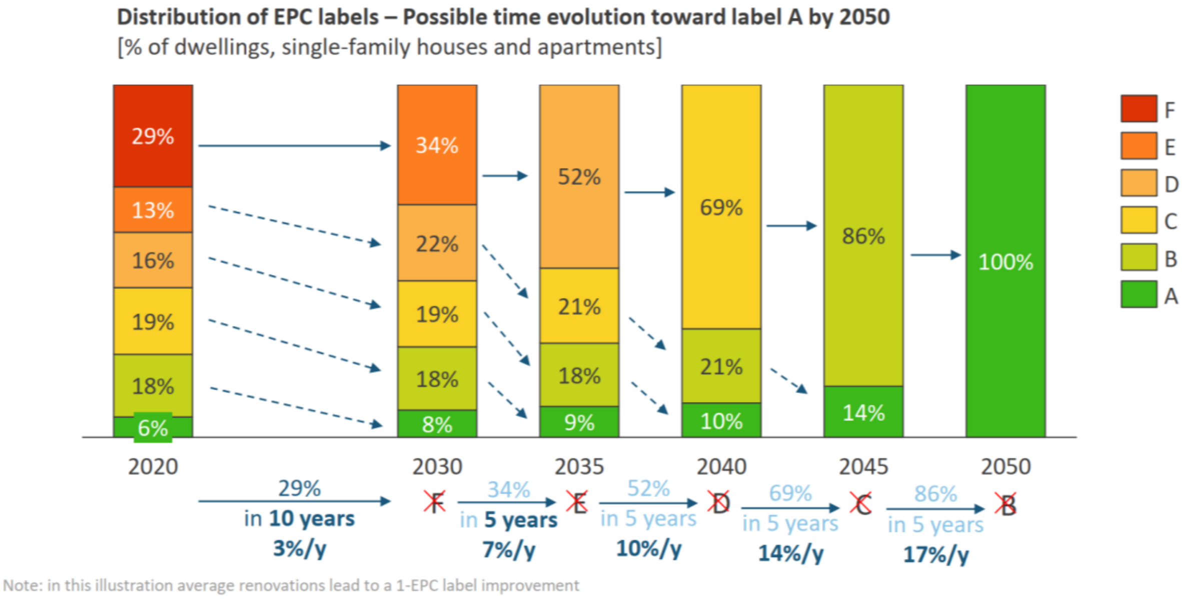


Figure 19: Distribution of EPC labels – Possible time evolution toward label A by 2050 (source: Climact and the Flemish Energy Agency).

Enforcement calendar schemes can be applied to all building segments, types and ownership structures. For non-residential and larger building owners, the enforcement calendar can be applied to their portfolio of buildings (i.e. assets). The owner/investor can then plan their portfolio investments in line with future MMR thresholds, which incentivises investments in high-performing buildings. Certain building/ownership types, such as public or non-residential buildings, could be mandated to meet the requirement a couple of years in advance and thus lead by example.

[79] This is a theoretical exercise as Flanders' actual LTRS goal for 2050 has not yet been agreed by the government.

4. STEP 2: SHORTLIST OF THE MOST RELEVANT MMR MODELS BASED ON KEY DESIGN OPTIONS

This section outlines the concept of six theoretical MMR models, based on the existing cases, literature review and stakeholder input. The models are **generalisations** of how MMR can be designed and enforced, from progressive minimum energy performance requirements to carbon-oriented requirements, indoor environmental quality, and renovation obligation at property transfers. Four central questions are answered for each model:

- What are the main policy objectives and the metric in which the requirement is expressed?
- When is action required? (timeline and trigger points)
- To which building segments and owner groups is the model applicable?
- How is compliance assured?

A qualitative and quantitative impact indication is provided for each model, based on a number of assumptions (specified in Appendix 3). The overall feasibility of the models is also qualitatively assessed and briefly discussed.

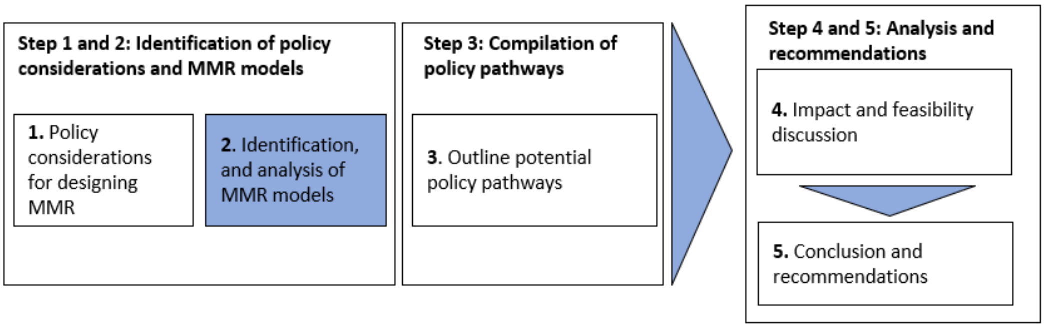


Figure 20: Research flow diagram - Step 2

The identified MMR types are divided into two categories, of which the first is linked to a predefined timeline (enforcement calendar), while the other relates to trigger points in the life of a building (see Figure 21), as discussed in Step 1.

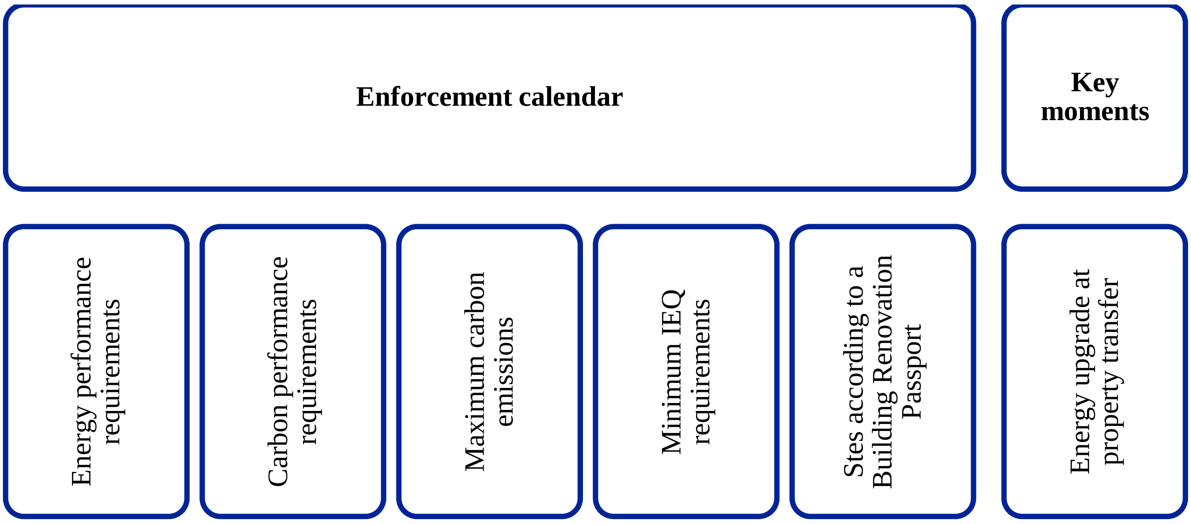


Figure 21: Overview of most relevant MMR models

4.1. MMR model 1: Progressive minimum energy performance requirements

The first model mirrors the existing cases in the UK, France and the Netherlands, where the performance thresholds are mainly defined by the building's energy performance level, defined through existing EPCs. The minimum performance threshold is progressively increased where all buildings below this threshold must be progressively upgraded before the hard deadlines (e.g. comply with EPC E by 2030, EPC D 2035 etc.). The long-term and progressive 'enforcement calendar' could alleviate most split-incentive barriers and give the construction supply chain and real estate investors time to anticipate change and adapt to the upcoming requirements.

The effectiveness of MMR model 1 varies depending on the quality of the regional/national EPC scheme, in terms of the share of building stock covered, reliability and existing database.

	Description
What:	The threshold could be expressed through the primary energy consumption of the building (kWh/m²/year), which is captured in the EPC.
When:	The first milestone could be set by 2030, to allow market players and building owners to anticipate and prepare for MMR. As a precondition, most of the targeted buildings must have an EPC. Subsequently, the minimum requirement is progressively tightened and enforced in five-year intervals, i.e. 2035, 2040, 2045, 2050.
Who:	The model could apply to all building and ownership types, but enforcement (e.g. time of compliance) and the compliance method (e.g. penalties) could differ depending on the building type (residential, non-residential, commercial, public buildings etc.), building use (home, office, industry, education), or ownership type (single owner, mixed ownership and real estate investors). The existing cases show that there is a value of keeping the requirement simple and straightforward. Therefore, the same milestone for all building types is preferred, although different building typologies can have different (lower/higher) requirements. For example, some building types that are less cost-optimal to renovate, such as heritage buildings, may have a lower threshold. It is also preferable that all building categories follow the same trajectory but with differentiated ambitions.
How:	This requires all buildings to have an EPC, as it is used to check eligibility and compliance. The EPCs ought also to be stored centrally in a digital database, to allow public authorities to check compliance and monitor progress. Compliance is verified based on the EPC rating. All buildings that are not complying with the requirement should present a valid reason or face a penalty. Compliance checks and EPC verification can be performed on a system level, using the existing EPC checks, which typically are based on random selection (e.g. spot checks on 5% of EPCs issued in a given year), or at trigger points in the building lifetime like property transfers.

	Meeting the requirement can also be a precondition to be allowed to rent out the building. Ensuring regular control is key to avoid rented buildings going to the black market.
Most prominent existing cases:	• The UK – The MEES in England and Wales sets minimum performance ratings for landlords (i.e. private rented properties). The standard is currently set at EPC rating E. There is also a pending regulation in Scotland. • The Netherlands – New requirement mandating EPC label C for office buildings from 2023. • France – The primary energy consumption of residential buildings (kWh/m²/year), defined by an EPC, may not exceed 330 kWh by 2028.

Table 4. Description of MMR Model 1

Evaluation

Figure 22 provides an overview of the impact of MMR model 1 in the pre-defined impact and feasibility categories. See Appendix 3 for a detailed analysis.

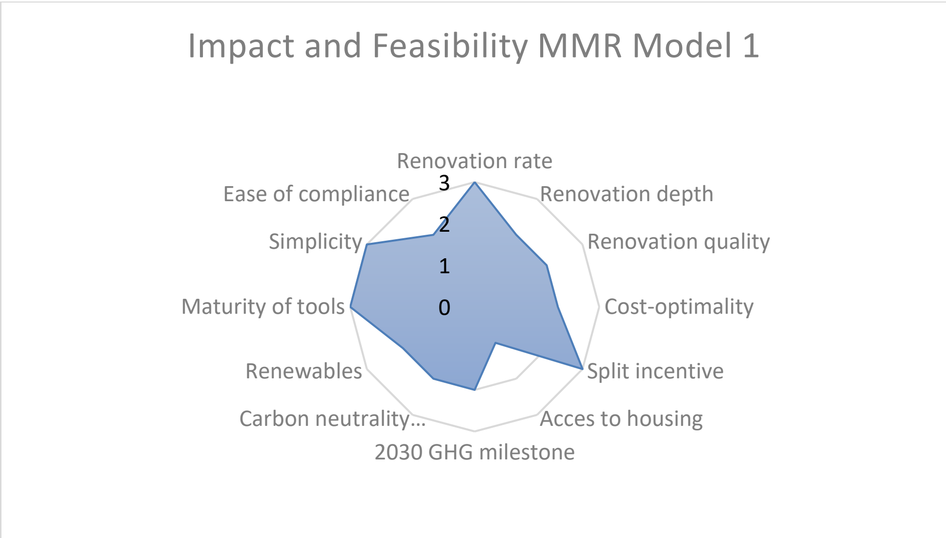


Figure 22: Impact and feasibility of MMR model 1

Impact evaluation: GOOD

MMR model 1 activates renovation of the worst-performing building stock, focusing mainly on the building's energy performance level. The EPC infrastructure is already in place, enabling an immediate impact on the market as building owners are at least partly aware of the EPC and its purpose. Yet problems remain with EPC quality and market penetration (with most buildings lacking an EPC), which could hamper the overall impact. The 'performance gap' could undermine the impact if not tackled in parallel, with the risk that the estimated energy savings do not materialise in actual energy savings.

The metric can build on the existing regulatory framework.

Feasibility evaluation: EXCELLENT

The simplicity is the main advantage of this option, and vulnerabilities like the reliability of EPCs can be addressed by harmonising the methodology. This MMR model has already been tested in the UK and is planned in the Netherlands and France, which demonstrates its feasibility.

Illustrative impact assessment of MMR model 1 (on the French residential building stock[80])

Modelled as a progressive ban on the worst-performing buildings from 2035 onwards towards an average 100kWh/m²/year by 2050, MMR model 1 reduces, by 2050 relative to 2020, the final energy consumption for heating by 39% and GHG emissions by between 39% and 56% (see Figure 23). The model also assumes a 'performance gap', that the achieved savings are lower than the estimated savings, reducing the impact by 16% for the final energy consumption and 7% for GHG emissions.

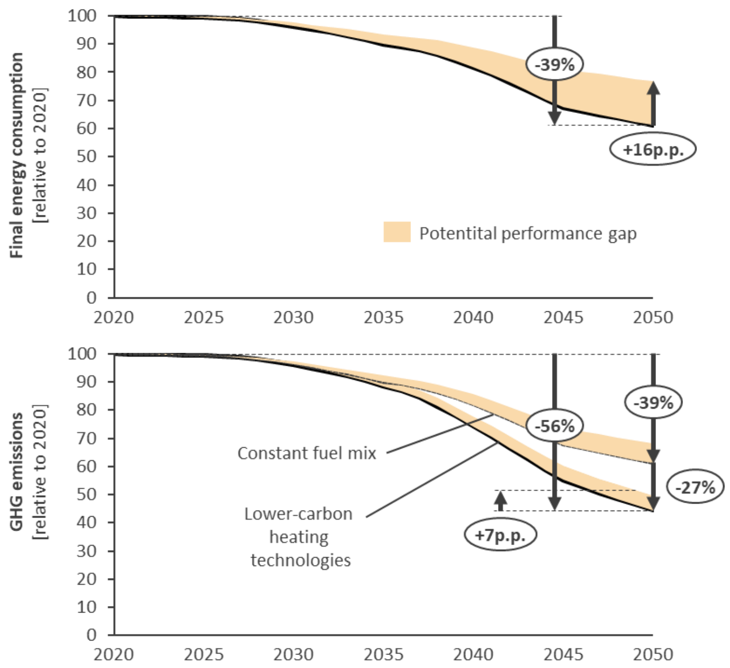


Figure 23: Illustrative impact assessment of MMR model 1 on the French residential building stock

Short-term actions to make it successful

- The EPC schemes need to be further developed and improved, to cover more buildings, and ensure higher availability, quality and reliability.
- The EPC data ought to be stored in a digital database to ensure an effective compliance procedure.
- Public buildings can lead by example, with enforcement calendar ahead of the other buildings.
- The EPC can be linked to other instruments to further improve its usability and the overall impact, including BRPs (as done in Flanders, Belgium), one-stop-shops (which is being done in Portugal) or the smart readiness indicator.
- Setting clear and long-term targets for the EPC requirement threshold will send a signal to the real estate market. Building owners should be informed about what is required from their building in 5, 10 and 20 years.
- Tailored recommendation advice instruments, such as BRPs, are needed to avoid economic and technical lock-in effects.

[80] Further details are provided in Appendix 3.

4.2. MMR model 2: Progressive minimum carbon performance requirements

This model mirrors the first but shifts the focus from energy performance to carbon performance associated with operational energy emissions. The MMR threshold is defined by the building's carbon dioxide (CO_2) emissions instead of the energy consumption level (kWh). The model assumes the carbon performance to be defined based on the estimated carbon emissions, taking into account the energy performance level and energy mix, which can be defined by the EPC, energy audit, or through utility bills and applying CO_2 emission factors. The model leaves room for building-specific trade-offs between energy efficiency upgrades and renewable energy investments.

	Description
What:	The MMR threshold is expressed in terms of carbon performance of heating needs (i.e. CO_2-eq/m²/year). It could be based on an EPC but using carbon performance as an indicator instead of the energy need (i.e. kWh/m²/year). Some EPCs would need to be adapted for this purpose.[81] Alternatively, the target can be expressed as primary energy consumption (kWh/m²/year) after subtracting on-site renewable energy production. The basic implementation confines the scope of the model to direct emissions, i.e. fuels burned on-site to produce heat.[82] The model can be further developed to consider the whole-life carbon impact of the building, taking into account the embodied carbon of materials and related processes.
When:	The first milestone could be set by 2030, to allow market players and building owners to anticipate and prepare for MMR. As a precondition, all the targeted buildings must have an EPC. Subsequently, the minimum requirement is progressively tightened and enforced in five-year intervals, i.e. 2035, 2040, 2045, 2050. The 2050 target could be aligned with the long-term decarbonisation goal.
Who:	The model can apply to all building and ownership types, but enforcement (e.g. time of compliance) and compliance method (e.g. penalties) could differ depending on the building type (residential, non-residential, commercial, public buildings etc.), building use (home, office, industry, education), or ownership type (single owner, mixed ownership and real estate investors).
How:	This requires all buildings to have an EPC, as it is used to check eligibility and compliance. The EPCs ought also to be stored centrally in a digital database, to allow public authorities to check compliance and monitor progress. The EPC must also be adapted to reliably include and display the carbon performance level.

[81] Several EPC schemes do indicate the CO_2 impact the building has, which is often a simple conversion from the energy need figure.
[82] Alternative scopes can include embodied emissions from the production of consumed electricity and heat (in case of heat networks) and embodied emissions from materials and products used in the renovation.

	Compliance is verified based on the EPC rating. All buildings that are not complying with the requirement should present a valid reason or face a penalty. Compliance checks and EPC verification can be performed at a system level using existing EPC checks, which typically are based on random selection (e.g. 5% of EPCs issued in a given year), or at trigger points in the building lifetime like property transfers. If the EPC includes indirect emissions from electricity and heat production, the national primary energy factors can be used by default. The building owner could have the possibility to provide proof of lower carbon intensity through their energy purchase contracts.
Existing cases:	Two existing cases do not exactly match this model but contain key design elements. • New York: Local law 97 (for larger buildings) which specifies annual building emission limits per m^2.

Table 5. Description of MMR Model 2

Figure 24 provides an overview of the impact of MMR model 2 in the pre-defined impact and feasibility categories. See Appendix 3 for a detailed analysis.

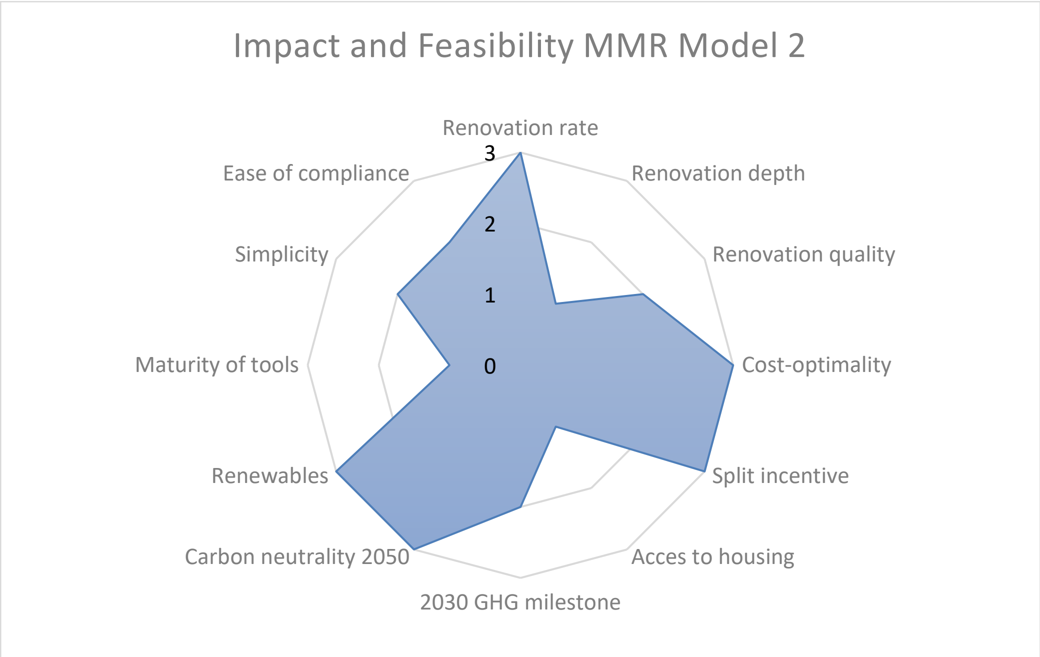


Figure 24: Impact and feasibility of MMR model 2

Evaluation

Impact evaluation: GOOD

The model focuses on carbon emissions, rather than building performance, encouraging techno-economic solutions towards this goal. At the same time, the model could create false confidence that the building envelope does not need to be upgraded to reach the future requirement and thus depraving end-users from some major benefits of a renovation. The model can also be seen as the first step to include whole-life carbon aspects, once there is one common standard for reporting and data collection. A database gathering whole-life carbon data of the building, enabling benchmarking, is another important precondition.

The EPC infrastructure is already in place, enabling an immediate impact on the market and high ease of implementation. Most Europeans are now aware of EPCs and have a basic understanding of their purpose. Yet major problems remain with their quality and market penetration (with most buildings lacking an EPC), which could hamper the overall impact.

The larger focus on renewables could reduce the (multiple) benefits of the renovation of the building envelope. For example, replacing fossil-based energy with renewable energy without improving the envelope may not bring a positive impact on comfort and wellbeing.

Feasibility evaluation: MODERATE

The model defines the threshold through CO_2 and is, therefore, better aligned with the EU's long-term objectives. The model could have a negative effect on data simplicity and compliance, even though CO_2 emissions already feature in the EPCs of some Member States, for example in France, Portugal and Poland.

Illustrative impact assessment of MMR model 2 (on the French residential buildings stock)[83]

Compared to MMR model 1, the further deployment of low-carbon and high-efficiency heating technologies leads to slightly greater final energy consumption reductions. As carbon neutrality is set as a long-term target for the renovation of existing buildings (for each building or similarly an average target for the building stock), GHG emissions are progressively reduced to zero through the deployment of renewable heat solutions – in complement to energy efficiency investments – to comply with minimum carbon performance requirements.[84] The modelling is based on the basic version of model 2 (i.e. not including whole-life carbon) (See Figure 25).

[83] Further details are provided in Appendix 3

[84] See also Table in Appendix 2

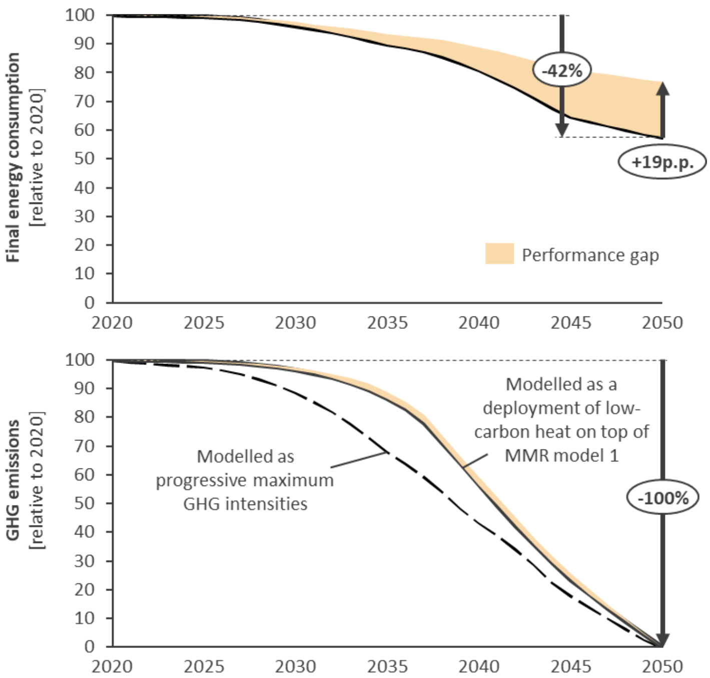


Figure 25: Illustrative impact assessment of MMR model 2 on the French residential building stock.

Short-term actions

- The EPC schemes need to be further developed and improved to cover more buildings, data gathering and storage while ensuring higher quality and reliability.
- The EPC data ought to be stored in a digital database to ensure an effective compliance procedure.
- The EPC must be adjusted to make it reliably display CO_2 emissions, which is already the case in several of the Member States.
- The MMR model will generate a boost of on-site renewable energy production, which might increase the need to stabilise the grid.
- Public buildings can lead by example, meeting their targets ahead of other buildings.
- Setting clear and long-term targets for the EPC requirement threshold will send a signal to the real estate market. Building owners should be informed about what is required from their building in 5, 10 and 20 years.

Medium-term actions

- The EPC can be coupled with other instruments to further improve its usability and the overall impact, including BRPs (as done in Flanders, Belgium), one-stop-shops (which is being done in Portugal) and the smart readiness indicator.
- A common standard is needed for how whole-life carbon impacts are calculated and data generated. This could be an extension of the existing Level(s) framework, and should:
  - Have a clear definition of CO_2 emissions related to the production of electricity and heat from the energy supplier.
  - Have a clear definition of CO_2 emissions related to renovation materials and processes. This should build on the existing database and collect data from the current renovation market to validate and improve these databases.
  - The MMR can gradually include lifecycle assessment (LCA) considerations defined concerning widely accepted LCA and

CEN/TC350 standards, Level(s) framework, and digital building logbooks.

4.3. MMR model 3: Progressive real carbon emissions budget

MMR model 3 defines a carbon emission budget for all targeted buildings. The emission metric is converted from total energy consumption and the energy mix of this consumption. The 'budget' can be defined based on an estimated carbon dioxide need for a certain building (e.g. x tonnes CO_2/m^2/year) or relative to its previous consumption levels (e.g. a reduction of 20% of the consumption compared to 2020 levels). The individual building budget could be derived from the national LTRS and local decarbonisation plans, to make sure the building contribute to the long-term objective. The emission budget limit ought to be 'normalised', depending on the building's size, usage, number of occupants and external factors (e.g. climate zone). This model alleviates the adverse impact of the 'performance gap'. Its purpose is to promote and ensure actual carbon emission reductions, which can be achieved through energy efficiency measures, renewables or changes in behaviour.

	Description
What:	The requirement applies to the GHG emissions per building, resulting from the real energy consumption during the building's operations (as a minimum scope). The CO_2 should be measured though smart meter data (heating and electricity) or utility bills if smart meters have not been rolled out. The emission factors of the heating sources need to be commonly agreed. The model can evolve to consider the whole-life carbon impact of the building, taking into account the embodied carbon of materials and related processes.
When:	The first milestone could be set for 2030, to allow market players and building owners to anticipate and prepare for MMR. Subsequently, the minimum requirement is progressively tightened and enforced in five-year intervals, i.e. 2035, 2040, 2045, 2050. The 2050 target could be aligned with the long-term decarbonisation goal, which would be simplified with the real carbon emission metric.
Who:	Existing cases of this model have focused on larger or non-residential buildings, as it can be sensitive to set a limit like this for private homeowners. The model can, however, apply to all building and ownership types; enforcement (e.g. time of compliance) and compliance method (e.g. penalties) could differ depending on the building type (residential, non-residential, commercial, public buildings etc), building use (home, office, industry, education), or ownership type (single owner, mixed ownership and real estate investors).
How:	The baseline against which carbon reduction is measured is first estimated based on smart meter data or utility bills (e.g. it could be an average from the last three years). With regular updates (at least every month) about carbon emissions, the building owner could get warnings and suggestions on how to reduce consumption. Monitoring and control would be based on energy bills or smart meters. If the scope embeds indirect emissions from electricity and heat production, the energy mix of energy providers should also be considered. The ease of monitoring would be improved if product declarations (including materials and chemicals) and energy

	consumption data were embedded in a digital building logbook. Controls could be automated and take place regularly. Non-compliance to bring a fine.
Existing cases:	New York City: Local law 97 (for larger buildings) which specifies annual building emission limits per m^2 Boulder: uses a point-based energy metric, but with some adjustments for the carbon intensity of specific fuels[85].

Table 6. Description of MMR Model 3

Figure 26 provides an overview of the impact of MMR model 3 in the pre-defined impact and feasibility categories. See Appendix 3 for a detailed qualitative analysis.

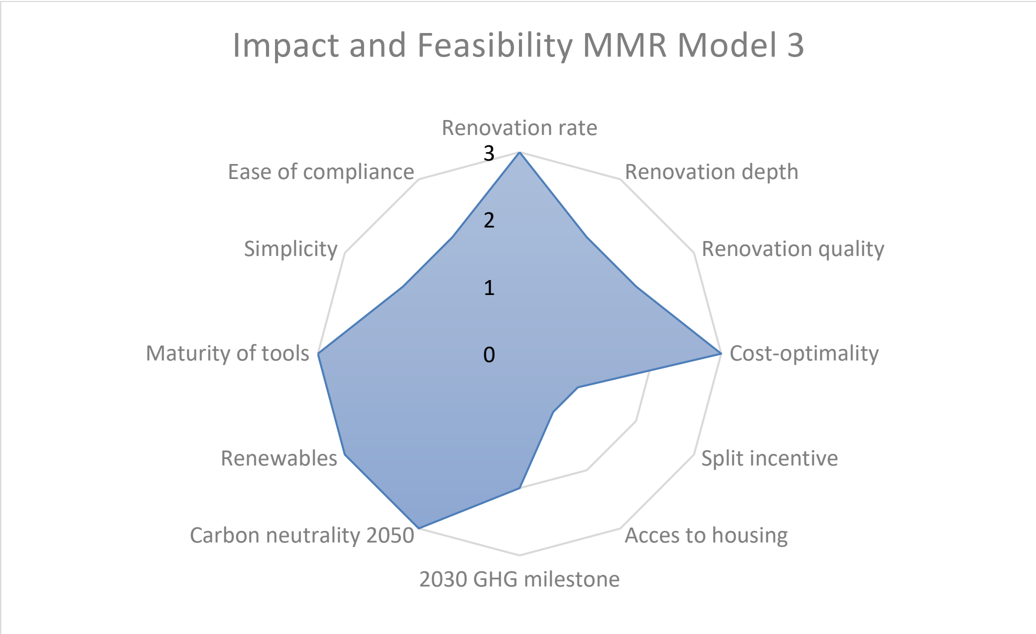


Figure 26. Feasibility and Impact analysis of MMR Model 3.

Evaluation

Impact evaluation: EXCELLENT
MMR model 3 alleviates the 'performance gap' by focusing on the actual carbon use, which is converted from energy consumption. The requirements set under this model would drive down carbon emissions in a cost-optimal way. As with MMR model 2, there is a risk that some of the multiple benefits from energy improvements would not be attained.
Feasibility evaluation: MODERATE
The indicator relates more to real energy savings and carbon emission reductions. Data privacy might be a barrier in some Member States. The model might not solve the split-incentive dilemma, as the responsibility for reducing energy use is not clearly defined. Landlords might encourage tenants to reduce their heating, instead of renovating. This model will be more difficult to implement for residential buildings.

[85] Nadel, S & Hinge A (2020) Mandatory Building Performance Standards: A Key Policy for Achieving Climate Goals. ACEEE (Available: Online)

However, it has been introduced in the United States for larger buildings, demonstrating its relative feasibility in the context of certain building segments.

Illustrative impact assessment

MMR model 3 is designed specifically to tackle the 'performance gap', highlighted in Figure 27, thanks to the reliance on actual energy consumption in the operation phase of a building and the related carbon emissions. No illustrative impact assessment has been made for model 3, given the theoretical scenario is similar to model 2 but without the risk of the "performance gap".

Short term actions:

- A just and fair definition of the 'carbon budget' is of utmost importance. The budget cannot simply be linear to the size of the building: for example, the increase in energy consumption from a one-person household to a two-person household is probably larger than from a five-person to a six-person household.
- The objective to achieve 'carbon neutrality' provides a clear long-term target for the market. It is necessary, however, to define the intermediate milestones. These can be set in *relative terms* compared to the current level of carbon emissions, or in *absolute levels* to be reached by certain milestones. Building owners should be informed about what is required from their building in 5, 10 and 20 years.
- Roll out smart meters to cover all buildings targeted with this model. EPCs could again be integrated as they provide useful and coherent additional information about the building's performance. Member States could enlarge their EPC scheme to also reflect real energy consumption, measured through smart meters rather than utility bills. This is already done in some cases (such as in Estonia and Sweden for certain buildings).
- Tailored recommendation advice instruments, such as BRPs, are needed to avoid economic and technical lock-in effects.
- If vulnerable groups are targeted with this model, adverse effects should be avoided with supporting measures (e.g. extra financial support) to avoid people simply turning off their heating to comply with the requirement.

Medium-term actions

- A common standard is needed for how whole-life carbon emissions are calculated, integrated and how thedata is generated. This could be an extension of the existing Level(s) framework, and should:
    - Have a clear definition of CO_2 emissions related to the production of electricity and heat from the energy supplier.
    - Have a clear definition of CO_2 emissions related to construction materials and processes. This should build on the existing experiences (e.g. EU's Level(s) framework and Buildings As Materials Banks project, as well as the Dutch Madaster and Swedish BASTA logbooks) and collect data from the current renovation market to validate and improve these databases.
- The MMR can gradually include lifecycle assessment (LCA) considerations defined with reference to widely accepted LCA and CEN/TC350 standards, Level(s) framework, Environmental Products Declaration and digital building logbooks.[86]

[86] The setting MMR thresholds could follow a similar approach to the EU sustainable finance taxonomy. The purpose of the taxonomy is to identify assets which are significantly contributing to climate change

4.4. MMR model 4: Mandatory improvements trigger by indoor environmental quality deficiencies

The model triggers renovations based on IEQ metrics, including indoor air quality, noise, sufficient light and temperature. The minimum requirement can be set for the whole building based on an aggregated score or for each building component. The purpose of MMR model 4 is to trigger the renovation of unhealthy buildings first; it can then be combined with one of the first MMR models. While many renovation measures improve both the IEQ and the building's carbon/energy footprint, combining them in the cost-optimal calculation would make sure MMR contributes to both.

Including IEQ indicators will help to raise awareness of other benefits of renovations beyond energy and carbon savings – benefits related to comfort, health and well-being as well as energy poverty alleviation. It could facilitate a more convincing narrative around MMR and its purposes.

	Description
What:	The minimum requirement is expressed in terms of IEQ indicators, such as air quality[87], thermal comfort[88], lighting[89] and noise[90].[91] The metric, if set for the whole building or certain components, should determine if the building is offering the occupants a decent living/working environment. The suggested renovation measure could be presented as an opportunity to improve the indoor environment and thus the quality of life of building occupants, while at the same time reducing energy needs.
When:	The first IEQ milestone could be set for 2030, to allow market players and building owners to anticipate and prepare for MMR. Subsequently, the model can be merged with MMR model 1-3 to broaden the scope.
Who:	The model can be applied to all building types and usages. It applies particularly well to certain building segments, including schools, hospitals, social housing and the private rental housing market, as these are segments where IEQ shortfalls have been identified and the societal costs estimated.[92]
How:	Member States can evolve their EPC schemes to ensure the quality of the indoor environment is considered. A few countries (e.g. Portugal and Greece) do already indicate the comfort level on their EPC label. EPCs have the potential to become effective instruments to track not only a building's energy performance but also its overall IEQ by

mitigation/adaptation, whereas the main purpose of the MMR is to identify the worst-performing segments. Setting the right MMR level will need to be proportional with compliance costs. Overall, considering the importance and urgency of improving the energy performance and decarbonising the building stock, the impact of compliance costs can be considered proportionate, especially given significant positive social and economic impacts the implementation of MMR can have.

[87] A building's ventilation rates are expressed in units of air flow rates per floor area, air flow rates per number of people, flow rates and air changes per hour (ACH).

[88] A comfortable temperature is typically around 21-24 degrees Celsius. A healthy building ought to be able to offer a comfortable temperature in cold winters and hot summers.

[89] Lighting includes both natural and artificial lighting. Illuminance levels (lux) and temperature of the lighting (Kelvin) are typically used as a metric of lighting.

[90] The acoustic environment must be designed to avoid these harmful effects. The criteria used to specify an acceptable acoustic environment are expressed in sound levels in decibels or sound frequencies like noise rating or noise criteria.

[91] BPIE (2018). "The Inner Value of a Building". (Available: Online)

[92] Buildings2030. (2018). "Quantifying the impact of a better indoor environment in schools, offices and hospitals". (Available: Online)

	providing evidence-based information (e.g. measurements, building occupant surveys, dynamic computer simulations). Measurements form the basis of quantitative indicators for the evaluation of the relevant parameters that can be included in EPCs.[93] Alternatively, an energy check/audit, potentially targeting priority households at risk of energy poverty, can determine if a building exceeds some certain defined 'health indicators', which could be indoor CO_2 levels, dampness or volatile organic compounds.
Existing cases:	• Denmark introduced renovation classes in its building regulation (BR2018) requiring the renovation of existing buildings to meet the same level as new buildings on certain IEQ parameters to be classified in the best EPC class. • The Active House, a worldwide quality stamp for comfortable and sustainable buildings, advises on elements important to people's lives and living conditions in their home. It issues its label for buildings that meet three specified requirements for indoor comfort, energy efficiency and the environment.

Table 7. Description of MMR Model 4

Figure 27 provides an overview of the impact of MMR model 4 in the pre-defined impact and feasibility categories. See **Appendix 3** for a detailed analysis.

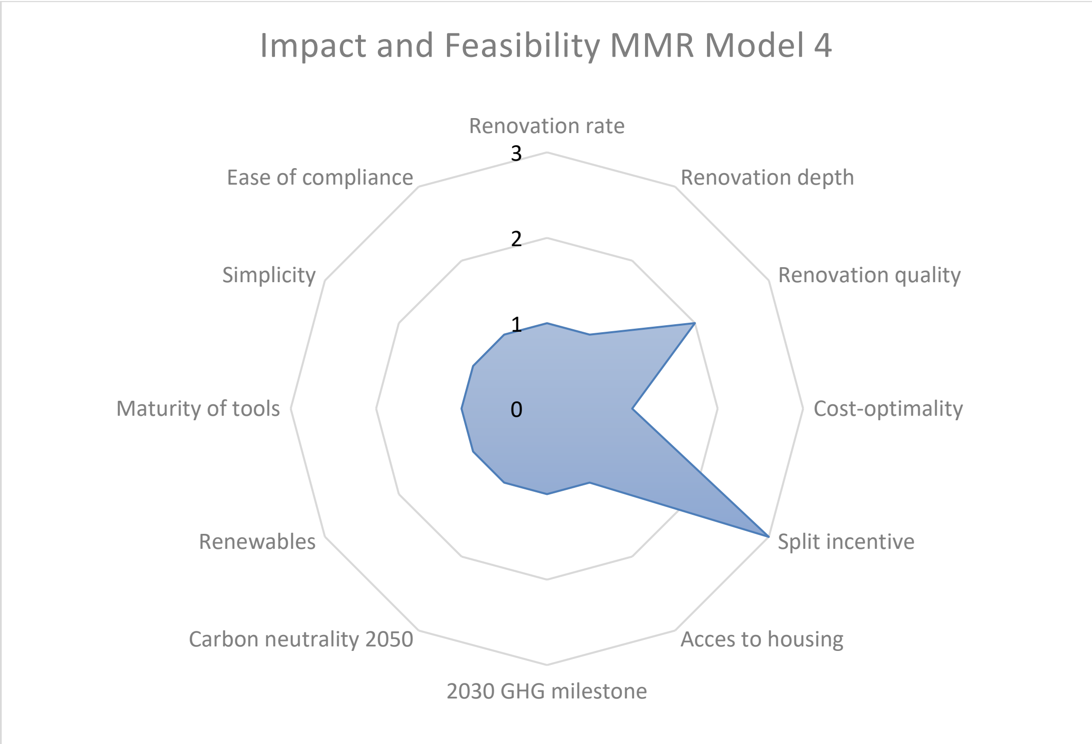


Figure 7: Impact and feasibility of MMR model 4

[93] For more information: BPIE. (2019). "How to integrate indoor environmental quality within national long-term renovation strategies" (Available: Online)

Evaluation

Impact evaluation: MODERATE
Tackles the renovation by introducing a more holistic approach. By requiring minimum IEQ levels, co-benefits such as lower health costs and increased productivity will be achieved and become more explicit. However, shares most of the weaknesses mentioned in the first model, e.g. the disconnect with the energy and carbon narrative.
Feasibility evaluation: POOR
The holistic approach comes at the price of simplicity. The EPC tools and methodologies would need to be adapted to include IEQ although there is currently no universal standard for how this can be done. Integrating IEQ metrics in the EPC would demand a more in-depth on-site visit and thus inflate the cost.

Illustrative impact assessment (on the French residential buildings stock)[94]

MMR model 4 is modelled as triggering the renovation of unhealthy buildings by 2030, beyond what is already triggered by MMR model 1 (the results are cumulated). Given that reasons to renovate go beyond energy efficiency, it is considered that the model will trigger deep renovations (both two-stage and one-stage renovations are considered). The impacts of this MMR model derive from deeper and earlier renovations (see Error! Reference source not found.28). It has the potential to increase the results r eached by 2030, further reducing the final energy consumption and the GHG emissions by up to 7% and 9% respectively compared to the 2020 level.

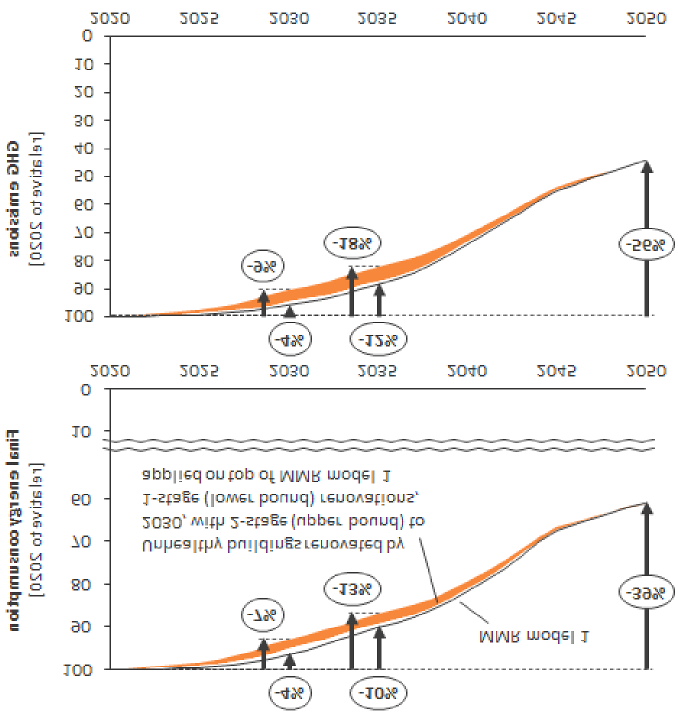


Figure 8: Illustrative impact assessment of MMR model 4 on the French residential buildings stock

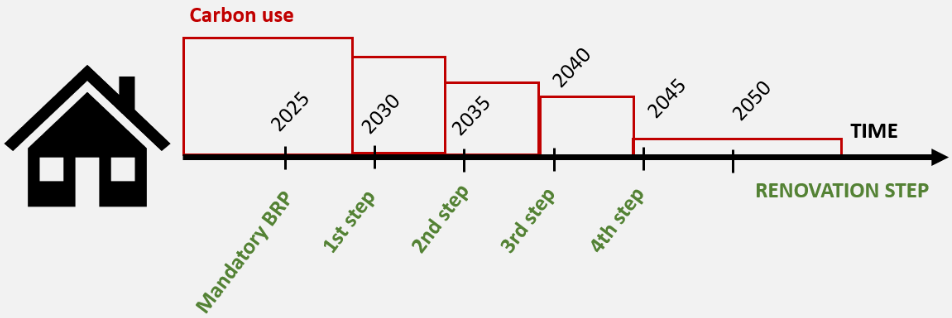
94 Further details are provided in Appendix 3

Short-term actions

- Clear links should be defined between IEQ and long-term renovation targets and strategies. The definition of what constitutes a 'healthy building' is a prerequisite, including indicators and metrics of how this could be evaluated.
- Training is needed for energy experts and other actors in the value chain to consider IEQ aspects in every phase of a building's lifetime.
- With remote working potentially becoming more frequent during and after the COVID-19 pandemic, IEQ becomes even more important for residential buildings as people spend more time at home.
- EPC schemes need to be further developed to integrate IEQ. EPCs should also be improved to cover more buildings and ensure higher quality and reliability.
- Public schools and hospitals can lead by example, as a good indoor environment is vital for learning and recovery from diseases.
- Setting clear and long-term targets for the IEQ requirement threshold will send a signal to the real estate the market. Building owners should be informed about what is required from their building in 5, 10 and 20 years.
- Tailored recommendation advice instruments, such as BRPs, are needed to avoid economic and technical lock-in effects while integrating the personal views of what a good indoor environment comprises for the specific tenants.

4.5. MMR model 5: Progressive implementation of pre-defined renovation steps based on a building renovation passport

This model sets up a progressive implementation calendar of renovation measures according to a BRP (i.e. individual renovation roadmaps), taking into account whole-life carbon considerations[95]. The renovation roadmap sets out the renovation steps the building owner must implement, in order for the building to become "2050 compliant". In contrast to the other models, the standard is individualised and can be adapted to the technical renovation possibilities of the building, as well as the preferences and financial constraint of the building owner.

	Description
What:	MMR Model 5 is defined in terms of renovation steps that need to be implemented by the building owner The renovation steps are clearly outlined in a BRP, which has been developed by an energy expert, and needs to be implemented within a certain timeframe (instead of all buildings meeting the EPC rating E, all targeted buildings must implement the first renovation step which are different for all building owners. An energy audit is a prerequisite for a BRP but also an opportunity to make a light LCA of the building. The whole-life carbon consideration will just inform the renovation decisions/steps to make sure they are taken to optimise the carbon reduction potential of the building (e.g. locally sourced material, natural components, and secure an end-of-life recycling of materials). The model also allows for a tailormade approach on a societal level, where the aggregated progress is aligned with the long-term target, as specified in the LTRS. The energy/carbon-saving per building then depends on the relative economic and technical feasibility for that building to reach net-zero. This top-down approach allows the public authorities to steer the decarbonisation effort so that it balances investments in energy efficiency and renewables. The model would also allow urban planners to better design district approaches where, for example, energy renovations are coupled with low-temperature district heating systems.
When:	Building owners are required to implement pre-defined renovation activities every five years: 2030, 2035, 2040, 2045, 2050, until the building is 'future-proof', meaning it performs as it should by 2050. The first requirement is to get a BRP. 

95 Other environmental, social and governance aspects (e.g. resource efficiency, construction and occupational health impacts, labour rights) and indoor environmenta quality aspects can also be included in the requirement.

	Preferably, the target for each building should be pegged to the 2050 decarbonisation target, where each building contributes to this according to its relative ability. The BRP will define the best-possible scenario for the individual building, considering the 2050 target but also the technical and economical feasibilities. Each building could contribute individually or at a district level. Current BRPs are not based on carbon performance, which means these instruments would have to be adapted for this purpose to be ready for implementation by 2030.
Who:	The model can apply to all building segments, types and owners.
How:	The first requirement for non-compliant buildings could be to obtain a BRP, which sets out the long-term renovation and renewable sourcing steps for the individual building. Financial support could be linked to the steps in the passport. The digital building logbook could be used to utilise the full potential of this model, such as allowing for public authorities to tailor policies to the actual needs of the building stock and monitor the progress towards the long-term target. It can also facilitate the integration of whole-life carbon by gathering and dispensing information on building components and materials.
Existing cases:	Most prominent building renovation passports are: • The Brussels LTRS foresees the implementation of a MEPS and roadmap for residential buildings (i.e. BRP). From 2030, sustainability criteria will be included in the region's EPC and BRP, which then could inform the MEPS triggered renovation measures. • The German Individueller Sanierungsfahrplan is a detailed building renovation passport based on an energy audit, focusing on measured energy. • The Flemish EPC features an automatic renovation roadmap, which means that all residents with an EPC also have a suggested roadmap for their building, focusing on measured energy.[96]

Table 8. Description of MMR Model 5

Figure 29. provides an overview of the impact of MMR model 5 in the pre-defined impact and feasibility categories. See Appendix 3 for a detailed analysis.

[96] See additional cases in Fabbri et al. (2020). "Technical study on the possible introduction of optional building renovation passports". European Commission. (Available: Online)

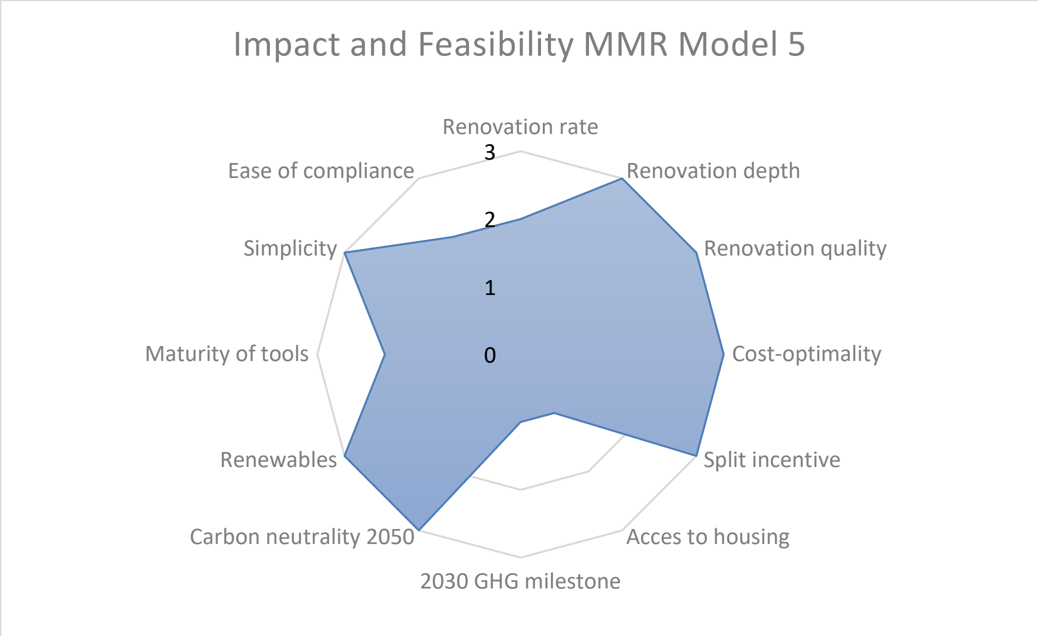


Figure 9: Impact and feasibility of MMR model 5

Evaluation

Impact evaluation: EXCELLENT
The model relies on the BRP, which defines clear renovation steps that need to be implemented and their costs for each building to comply with the MMR. The overall quality of the implemented measures is higher because of the tailored advice and aligned with the long-term target set out in the countries LTRS. The BRP avoids economic and technical lock-in effects, where the cost-optimal path to a 2050-compliant building no longer is viable. The model includes renewable on-site production as part of the renovation steps identified in the BRP, meaning that an energy expert balances the energy efficiency and renewable improvements that are needed. The model also allows building owners to make better decisions because tailored renovation advice.
Feasibility evaluation: MODERATE
Implementing this model would not be that complex, as some of the conditions of producing a BRP are already in place and a few examples already exist, which could be replicated. The whole-life carbon consideration ought to based on a common standard for the data and reporting procedures and build on existing experiences with LCA, which will require some extra training for the auditors. While several countries are looking to implement a BRP in some capacity, there is a long way to go to reach the same market penetration as EPCs (which also might not be enough). Requesting building owners to get a BRP would create a challenging demand for certified auditors who can perform this work.

Illustrative impact assessment (on the French residential buildings stock)[97]

MMR model 5 is expected to trigger earlier renovations thanks to the provision of quality information to households via the deployment of BRPs. However, assuming that the “energy efficiency first” principle applies to the implementation steps of the renovation

[97] Further details are provided in Appendix 3

passport (i.e. the first steps consist of energy efficiency measures and the switch to low-carbon heat solutions occurs later), large carbon emission reductions are only obtained during the last part of the time horizon (see Figure 30). The orange line indicates the added impact from MMR model 5, relative to model 1 and 2.

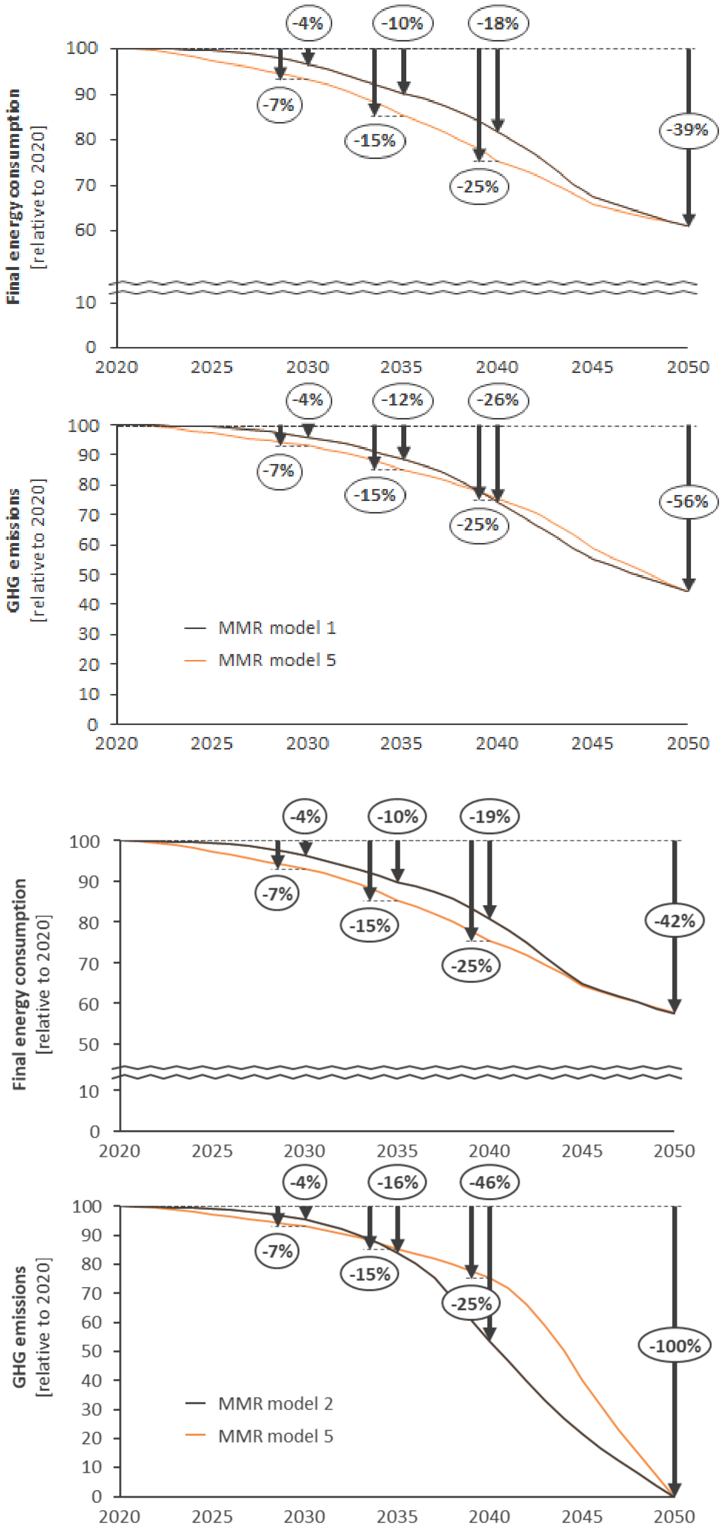


Figure 10: Illustrative impact assessment of MMR model 5 on the French residential buildings stock

Short term actions:

- Evolve existing BRPs to integrate a light LCA, considering the whole-life carbon aspects based on Level(s). This will require extra training for auditors but require that much extra time on-site.
- The BRP ought to be 'user-friendly' and contribute to making the renovation process more comprehensible for the building owner.
- Integrated renovation services, like one-stop-shops, can facilitate a smoother process for the building owner, by directing them to the appropriate expert, installer or financial institutions.
- Member States should be encouraged to subsidise the cost for the development of the BRP to a level where it becomes attractive to building owners. The subsidy can be reduced when the instrument has penetrated the market. Quality of the BRP is crucial to gain trust for the instrument and its usability.[98]
- The success of the implementation of the BRP and related MMR is dependent on an increase in competence and skills of the construction workforce.
- Public buildings can lead by example, meeting their targets ahead of other buildings.

[98] See additional cases in Fabbri et al. (2020). "Technical study on the possible introduction of optional building renovation passports". European Commission. (Available: Online)

4.6. MMR model 6: Renovation obligation linked to real estate transactions for all building non-compliant in 2050

This model foresees buildings being renovated in conjunction with real estate transactions. Both residential and non-residential buildings could be subject to progressively more demanding MMR when the building changes owner. For example, all owners of buildings with an EPC rating of B, or worse, must improve their building, if sold. The MMR Model will boost the demand for high-performing buildings.

Buildings that are not sold or rented out do not have to be upgraded under this MMR model. MMR model 6 can easily be combined with either MMR model 1,2 or 3, as a complementary requirement.

	Description
What:	All buildings below a certain threshold, which could be defined according to the EPC rating, must be upgraded to a better standard when there is a change of occupancy as a pre-condition for any real estate transaction. The threshold, defined by the building's energy efficiency or climate performance level, should be higher than in MMR models 1 and 2. Preferably the threshold should be aligned with the 2050 climate target, which could be defined in the country's LTRS, aligned with nearly zero-energy building standards, or correspond to the EU Taxonomy Regulation.
When:	The requirement applies after the sale deed has been signed (i.e. building officially has a new owner). The MMR should allow for a grace period, giving the new owner time to comply with the requirement.
Who:	Homeowners or real estate investors, who buy a building not complying with the minimum threshold.
How:	The (local) public authorities are typically informed about property transfers in their region, which should be accompanied by an EPC. The buyer of the building is aware of the requirement before the purchase and is given a grace period until a certain date by which the upgrade ought to be completed. Preferably these steps are defined by a BRP or an EPC with tailored renovation advice. The updated EPC, including the completed renovation, can be used to prove compliance with the requirements. Financial subsidies linked to the MMR model should focus on fostering renovations that go deeper than the minimum requirement – for example, to incentivise people to make their building 'future proof' in one deep renovation.
Existing cases:	Flanders – as of 2021, all non-residential buildings are required to undergo a thorough energy renovation within five years after purchase to reduce their climate footprint. See the case study in Appendix 1.

Table 9. Description of MMR Model 6

Figure 31 provides an overview of the impact of MMR model 6 in the pre-defined impact and feasibility categories. See Appendix 3 MMR model 6 for a detailed analysis.

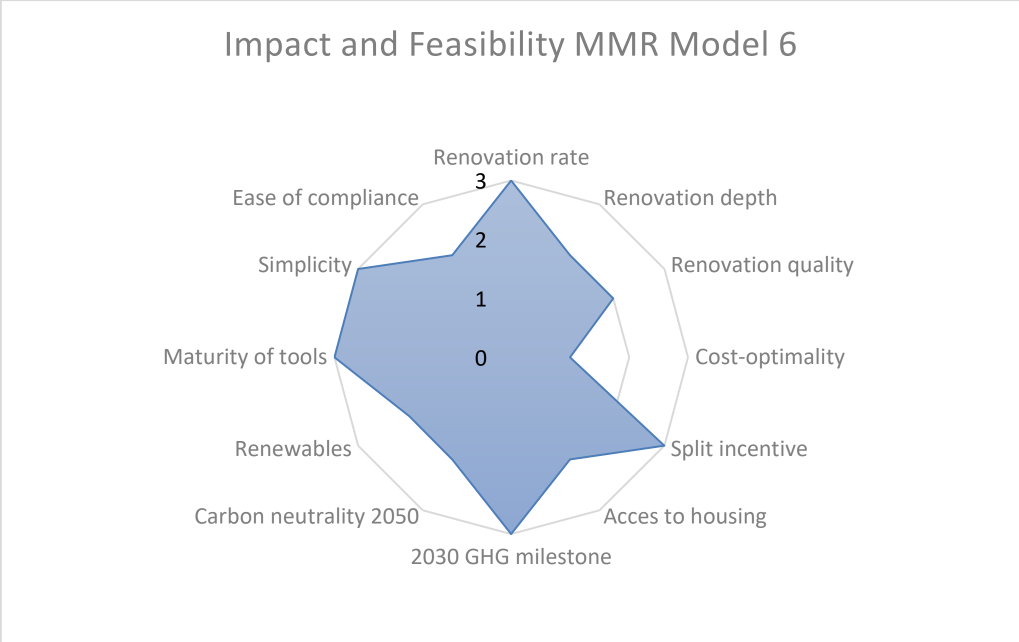


Figure 11: Impact and feasibility of MMR model 6

Evaluation

Impact evaluation: GOOD

Triggering renovations in conjunction with property transfers can contribute to half of the targeted renovation rate (i.e. 3%/year deep renovations), which would initially be slowed down by the grace period[99]. The most logical metric for this model is energy need (i.e. kWh/m²) but it can also be linked to carbon impact (CO_2/m^2). The model does not influence buildings that are not being sold, or rented out, before 2050. The requirement could have a negative effect on the real estate market, as it brings an additional cost to most purchases.

Feasibility evaluation: EXCELLENT

Using real estate transactions as the trigger point simplifies the compliance procedures, as these are already reported to the local authorities. Most Member States also require the building to have an EPC when being sold or rented out.

Illustrative impact assessment (on the French residential buildings stock[100])

MMR model 5 is modelled as capturing the 1.9%/year sales from 2025 onwards to trigger deep energy renovations (see Figure 32). Beyond what is already triggered by MMR model 1, MMR model 5 fosters earlier and deeper energy renovations. It has the potential to increase the results reached by 2030, further reducing the final energy consumption by between 6% (two-stage renovations) and 8% (one-stage renovations), and GHG emissions by between 7% (two-stage renovations) and 12% (one-stage renovations) from the baseline in 2020.

[99] House transactions cover to ~2.3% of the housing stock (5 million dwellings a year including new builds) [source: European Central Bank]; new builds contribute 0.5%/year [source: Deloitte 2017 Completed dwellings].
[100] Further details are provided in Appendix 3

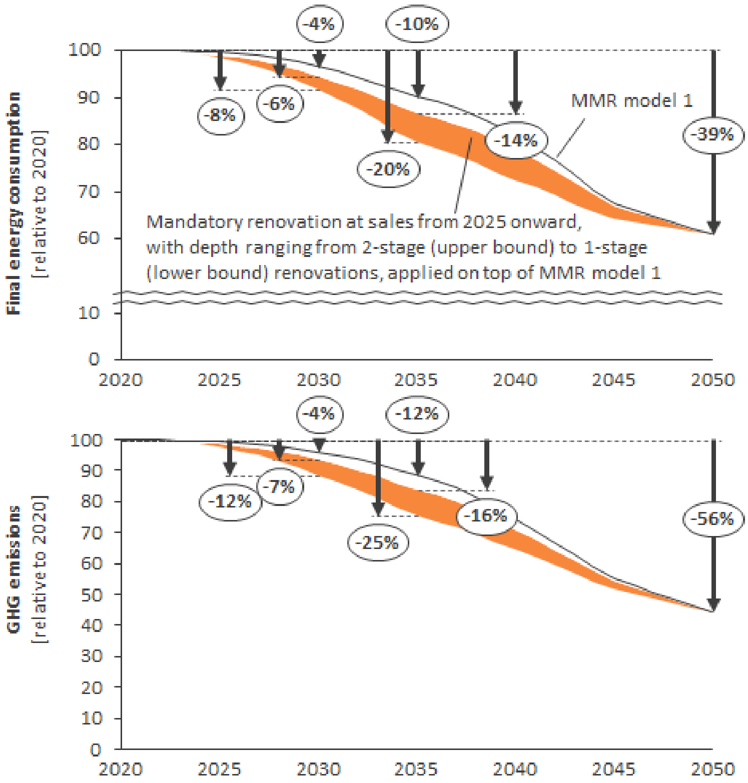


Figure 12: Illustrative impact assessment of MMR model 5 on the French residential buildings stock cumulative to the MMR model 1.

Short-term actions

- Since this MMR model targets real estate transactions that will take place in the short term, and on average once for each building by 2050, clear communication between all stakeholders is very important. There must be clear and effective communication between the real-estate sector, public authorities, renovation professionals and building owners. The role of the real-estate sector is essential, and effort should be made to make sure they understand the goals and societal benefits of the policy instrument.
- Clear communication of estimated renovation costs on top of the housing price during sales is crucial for building owners to understand the real costs.
- To foster one-time deep renovations, the renovation is ideally implemented at purchase and not within a predefined time frame after the transaction. For this to be possible, the quality and availability of deep renovation services need to be drastically improved (quality professionals easy to find, quick and qualitative project definition, quick implementation of the works).
- For step-by-step renovation approaches, the mandatory energy performance of building components should be related to the levels identified in the BRP.

4.7. Overview of the impact and feasibility of the MMR models

Table 10 summarises the qualitative impact and feasibility assessment of the six MMR models.

Excellent	Good	Moderate	Poor

MMR Model	Impact	Feasibility	Discussion of the impact
1 MMR based on energy performance			The implementation of the first MMR model can be based on existing, yet improved, EPC regimes. The impact can be considerable but depends on the policy design, including the level of the requirement, exemptions and monitoring and compliance framework. The model does not integrate operational or embedded carbon emissions, which might cause an unbalance between energy efficiency and renewable investments.
2 MMR based on carbon performance			The implementation of this MMR can be based on existing, yet adjusted and improved, EPC regimes. The model focuses on carbon emissions, rather than energy performance, enabling cost-optimal solutions. At the same time, the model could create a false belief that the building envelope does not need to be upgraded to reach the future requirement. The model can also be seen as the first step to include whole-life carbon aspects, which needs to evolve further, in terms of a common standard and a database, to be able to underpin this MMR model. The model can have a negative effect on data simplicity and compliance, even though CO_2 emissions from operational energy are already featured in the EPCs of some Member States.
3 MMR based on a real consumption carbon budget			MMR model 3 alleviates the 'performance gap' by focusing on actual carbon consumption. The requirements set under this model would drive down carbon emissions in a cost-optimal way. Data limitations might be a barrier in some Member States. The model will not solve the split-incentive dilemma, as the responsibility for reducing energy use is not defined. Landlords might encourage tenants to reduce their energy use instead of renovating.
4 MMR based on IEQ indicators			A minimum IEQ requirement would trigger multiple benefits, such as lower health costs and increased productivity. There is a risk that the renovations would be fragmented and designed to fix the specific IEQ deficit (e.g. improve ventilation if air quality is too bad). The holistic approach comes at the price of simplicity. The EPC tools and methodologies would need to be adapted to

			include IEQ although there is currently no universal standard of how this can be done. Integrating IEQ metrics in the EPC would demand a more in-depth on-site visit and thus inflate the cost.
5 MMR based on a building renovation passport			The model relies on the BRP, which defines clear renovation steps that need to be implemented and their costs for each building. The overall quality of the implemented measures is higher and aligned with the long-term target (i.e. avoids economic and technical lock-in effects). Implementing this model would not be too complex, as some of the conditions of producing a BRP are already in place and a few examples already exist, which could be replicated. An energy audit is a prerequisite for a BRP but also an opportunity to make a light LCA of the building., which will require some additional training for the auditors. The whole-life carbon consideration will just inform the renovation decisions/steps to make sure they are taken to optimise the carbon reduction potential of the building (e.g. locally sourced material, natural components, and secure an end-of-life recycling of materials).
6 MMR linked to property transfers			Triggering renovations in conjunction with property transfers can contribute to half of the targeted renovation rate (i.e. 3%/year deep renovations). The most logical metric for this model is energy need (i.e. kWh/m²) but it can also be linked to carbon impact (CO_2/m²). Using real estate transactions as the trigger point simplifies the compliance procedures, as these are already reported to the local authorities. Most Member States also require the building to have an EPC when being sold or rented out.

Table 10. Overview of feasibility and impact of MMR models

5. STEP 3: POLICY PATHWAYS TO ESTABLISH MMR FOR EXISTING BUILDINGS IN THE EU

Step 3 identifies paths the EU can take to enforce or support the development and formulation of MMR for existing buildings, including the wider policy framework, as discussed in Step 1. While there are many ways forward for the EU, this section outlines four pathways that would be effective while showcasing the flexibility and difference between different MMR models.

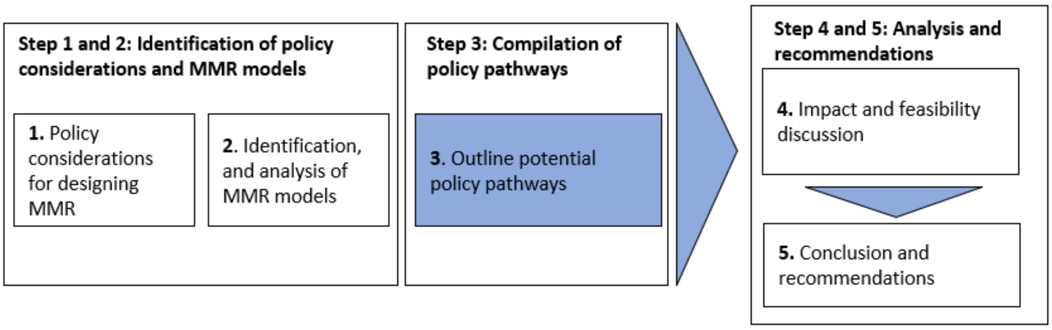


Figure 13: Research flow diagram - Step 3

The decarbonisation of the European building stock needs a considerable boost to achieve a climate-neutral Europe by 2050. The improvement of existing buildings remains too slow, with a renovation rate that lingers at 1%, while the deep renovation rate is only around 0.2%.[101] Many barriers are hampering a transformation of the building stock, including lack of interest, insufficient understanding of energy use and savings, 'split incentives'[102], and the current capacity of the construction value chain. MMR for existing buildings has gained traction as a solution to overcome many of these obstacles.

All the EU Member States must establish an LTRS to support the transformation of their building stocks to become highly energy efficient and decarbonised by 2050, including milestones for 2030 and 2040. LTRS must include an overview of the national building stock policies and actions to stimulate cost-effective deep renovation of buildings and to target the worst-performing buildings.

The recently submitted LTRS and the national energy and climate plans will likely confirm that the new and planned measures are not enough to be on track for the 2050 objectives.[103] [104]There is a window of opportunity to introduce more stringent policies and measures to meet the 2050 target, including MMR for existing buildings. The Renovation Wave strategy also introduces a number of provisions, which will introduce, and support, MMR (see Figure 34).

[101] Ipsos & Navigant (2019) Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU. European Commission. (Available: Online)
[102] Split incentives occur when those responsible for paying energy bills (often the tenant) are not the same person as those making the capital investment decisions (often the landlord or building owner).
[103] See review of the first 12 LTRS by BPIE. (2020). "A review of EU Member States' 2020 Long-term Renovation Strategies." Available: Online)
[104] See European Commission's assessment of National Energy & Climate Plans, which concludes "as far as energy efficiency is concerned, although the ambition level is higher than in the draft NECPs, the cumulative impact of the different NECPs still falls short of the existing energy efficiency target of 32.5%."

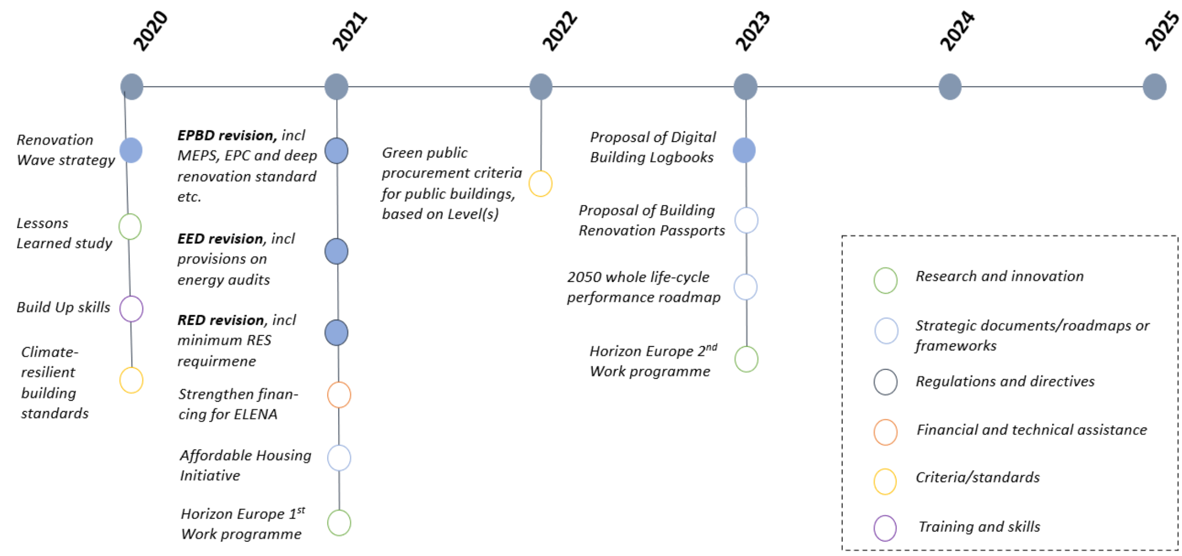


Figure 14: Renovation Wave Strategy - relevant provision for MMR

As discussed in Step 1, MMR for existing buildings could contribute to the objective of several ongoing and new strategies. MMR could contribute significantly to the Renovation Wave by triggering renovation works and providing a clear signal to the market. There are synergies with other initiatives, including the New Industrial Strategy for Europe, the SME Strategy for a Sustainable and Digital Europe, as well as the Circular Economy Action Plan and disclosures relating to sustainable investments and sustainability risks.

The objectives of the policy pathways are the same, but their approaches differ.

- Policy Pathway 1 aims to remove the worst-performing building in terms of energy performance by introducing a progressive minimum energy performance requirement for the existing buildings. The pathway has been designed to utilise existing infrastructure (esp. the EPC schemes) and existing directives (esp. the EPBD). The boost in demand for energy renovations will drive change in the construction value chain by requiring an improvement of the worst-performing building segments.
- Policy pathway 2 aims to get carbon emissions related to operational energy consumption down to zero by 2050. MMR linked to carbon emissions, instead of energy performance, can better align the requirement with the long-term climate objectives, which are expressed in carbon emission levels. This MMR can drive increased demand for renovations, with an optimal balance between energy efficiency and renewable energy investments.
- Policy pathway 3 aims to get all carbon emissions down to zero by 2050 by considering whole-life carbon emissions. An MMR considering all carbon emissions can better align the requirement with the long-term carbon objectives, yet is much more complex to design and put in practice. A whole-life carbon standard would tend to favour the reuse of buildings and their materials as much as possible, and influence design decisions in both renovations and new constructions.
- Policy pathway 4: this pathway focus on capturing the trigger points in the building’s lifecycle to foster renovations through natural trigger points in a buildings life-cycle. A renovation obligation linked to property transfers for all buildings, together with an MMR based on progressive energy performance requirements, will trigger even greater demand for renovation works and move all buildings towards the 2050 target.

5.1. Policy pathway 1: Progressive minimum energy performance requirement

Policy Pathway 1 aims to alleviate the worst-performing building in terms of energy efficiency by introducing a progressive minimum energy performance requirement for the existing buildings. The pathway has been designed to utilise existing infrastructure (esp. the EPC schemes) and existing directives (esp. the EPBD). The boost in demand for energy renovations will drive change in the construction value chain by requiring an improvement of the worst-performing building segments.

Policy pathway 1 sets progressive minimum energy performance requirements (expressed in $kWh/m^2/year$) and can, therefore, build on the existing policy framework. This MMR may be deployed via a new article in the EPBD and linked to the EPCs and LTRS.

The existing cases show that successful MMR must be integrated into a wider policy framework and be based on long-term progressive enforcement perspectives. To make policy pathway 1 effective, the EU and its Member States must support it through:

- Improvement of the penetration, reliability and awareness of EPCs, for example through higher and more harmonised requirements by the EU.
- Investment in skills in the construction value chain to make sure there are enough certified workers to carry out the additional work.
- Promoting the deployment of appropriate financing schemes, to ensure the accessibility and affordability of the renovation investments.
- Directing financial support to limit the negative effect on vulnerable groups, as well as to incentivise people to upgrade their building beyond the minimum requirement.
- Facilitating forums for good practice exchange.
- Investing in awareness-raising activities among the public.
- Setting up a systematic approach to address the 'performance gap'[105]

Existing cases to learn from:

- The MEES in England and Wales set minimum performance ratings for landlords (i.e. private rented properties). The standard is currently set at EPC rating E. There is also a pending regulation in Scotland.
- The Netherlands – New requirement mandating EPC label C for office buildings from 2023.
- France – The primary energy consumption of residential buildings ($kWh/m^2/year$), defined by an EPC, may not exceed 330 kWh by 2028.

Pros	Cons
+ Relatively easy to implement + Builds on existing cases + Easy for end-users to grasp	- The performance gap is a risk - Risk that whole-life carbon emissions may be overlooked if not addressed by another measure

[105] The performance gap, referred here, is the disparity that can be found between the energy use predicted in the design stage of buildings and the energy use of those buildings in operation.

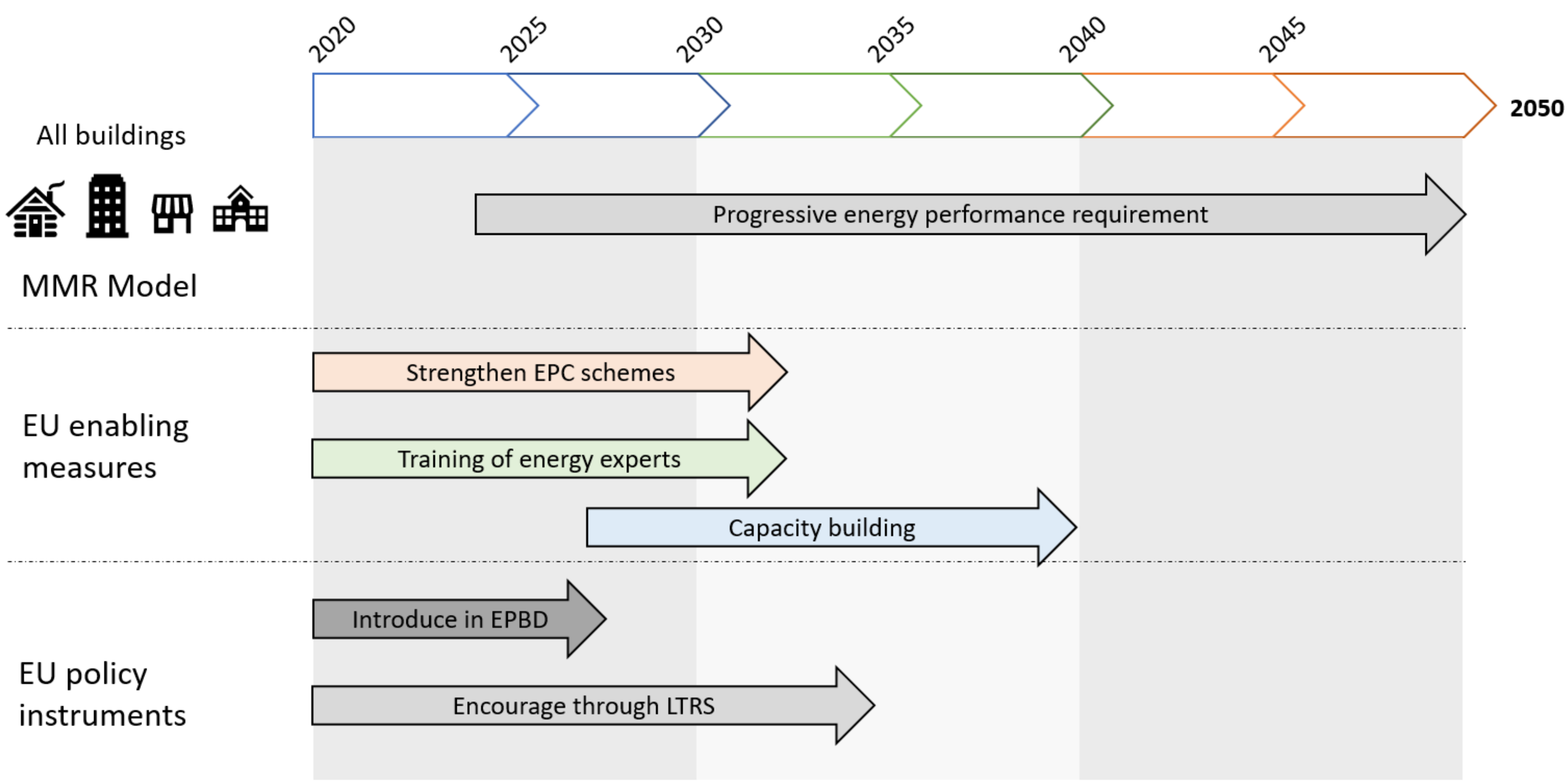


Figure 15: Policy pathway 1 - Timeline

5.2. Policy pathway 2: Progressive minimum carbon performance requirement

Policy pathway 2 aims to get carbon emissions related to operational energy consumption down to zero by 2050. MMR linked to carbon emissions, instead of energy performance, can better align the requirement with the long-term climate objectives, which are expressed in carbon emission levels. This MMR can drive increased demand for renovations, with an optimal balance between energy efficiency and renewable energy investments.

Policy pathway 2 sets progressive minimum carbon performance requirements (expressed in CO_2/m^2/year and relating to operational energy consumption). For residential buildings, the pathway foresees that EPCs are updated to feature the carbon performance of the building more reliably. For non-residential buildings, the carbon performance is derived from the actual energy consumption (e.g. as displayed by smart meters) and the local energy mix and the CO_2 emission factor. Carbon performance, in this pathway, focuses on the emissions as a result of the operational energy consumption. It does not include embodied carbon emissions, which a whole-life carbon approach would do (see Policy pathway 3). This carbon-oriented MMR would, however, require a broader regulatory framework.

To make policy pathway 2 effective, the EU and its Member States must support it through:

- Updating EPCs to feature the building's carbon performance, while also improving the instrument's penetration, reliability and awareness. Under the EPBD, Member States already can define additional numeric indicators to express the energy performance of buildings, including in terms of greenhouse gas (GHG) emission produced in kgCO2eq/(m^2/year), in addition to primary energy use.
- Exploring how to set a carbon performance requirement that balances energy efficiency and renewable energy investments.
- Investing in skills, communication, financial support and good practice forums, as described under policy pathway 1.

Existing cases to learn from:

- New York City, The United States: Local law 97 (for larger buildings) which specifies annual CO_2 emission caps per building, depending on their size, number of occupant and use.
- France: The Tertiary Renovation Decree (Décret Tertiaire) requires all buildings used by the tertiary sector to reduce their energy consumption by 40% by 2030. Similar to the New York case but sets the threshold in energy use instead of carbon emissions.
- Boston, Massachusetts, The United States: The city is planning to introduce mandatory carbon emissions targets by building type that decreases over time[106].

Pros	Cons
+ Aligned with 2050 target + Easy for end-users to grasp + Cost-optimal balance between energy efficiency and renewables	- Requires considerable revisions of the existing legislative basis - Some multiple benefits (better comfort, health and productivity gains) of energy efficiency improvements at risk of being missed

[106] See Nadel, S & Hinge A (2020) Mandatory Building Performance Standards: A Key Policy for Achieving Climate Goals. ACEEE (Available: Online)

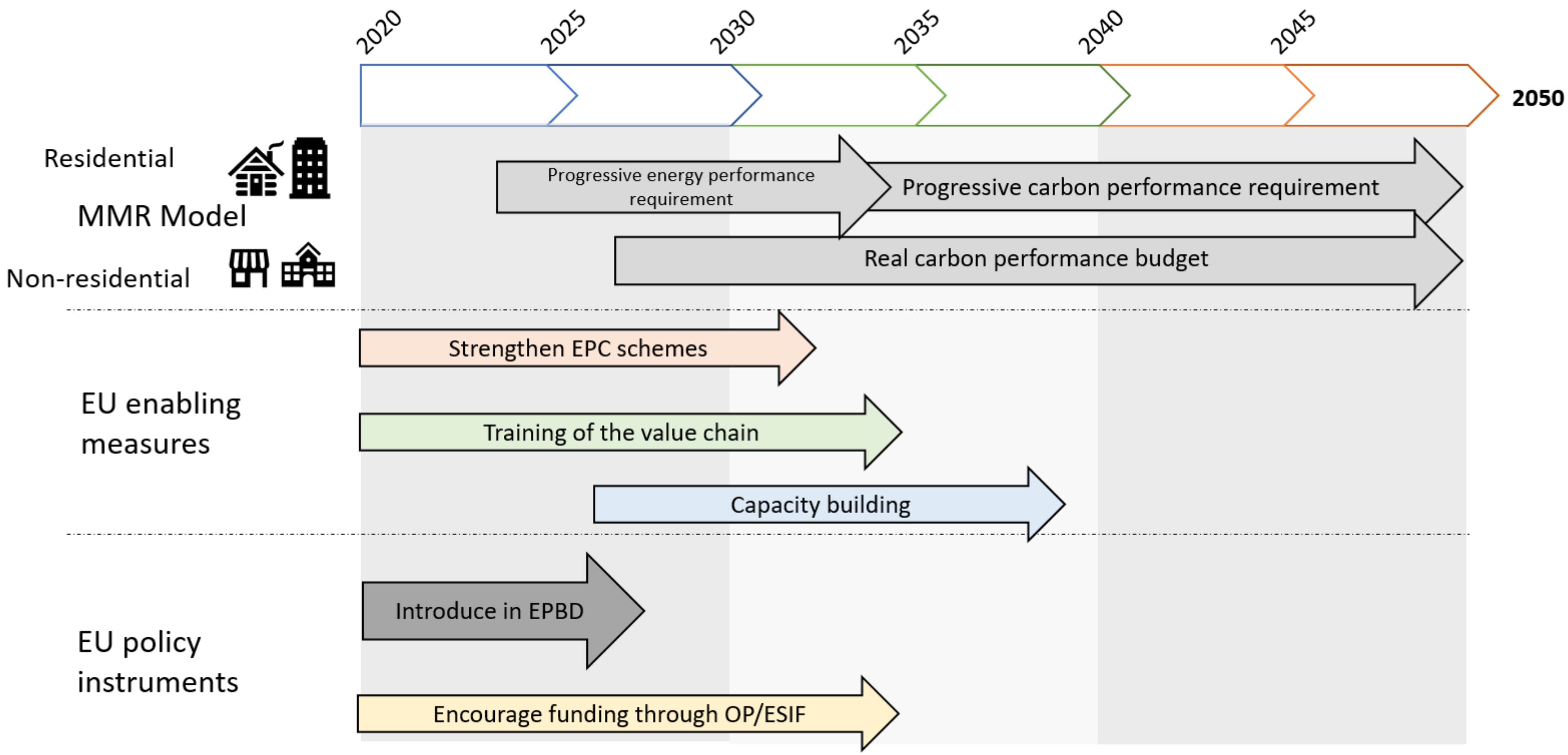


Figure 16: Policy pathway 2 - Timeline

5.3. Policy pathway 3: Progressive minimum carbon performance requirement, considering whole-life carbon aspects

Policy pathway 3 aims to get all carbon emissions down to zero by 2050 by integrating all related carbon emissions. An MMR linked to carbon emissions can better align the requirement with the long-term climate objectives, yet is more complex to design and put in practice, because there is no common standard[107] for how data can be gathered and stored, and no database of whole-life carbon data[108] that can be used for benchmarking purposes. A whole-life carbon standard would have circularity as a key principle and would tend to favour the reuse of buildings and their materials as much as possible, and influence design decisions in both renovations and new constructions.

Policy pathway 3 sets progressive minimum carbon performance requirements. The carbon performance requirement should gradually go on to also consider lifecycle performance when the renovation plan is developed for the individual buildings. The pathway relies on reliable building data being available and attainable, and tailored renovation recommendations for the end-users, which can be ensured by the introduction of digital building logbooks[109] and building renovation passports[110]. The whole-life carbon aspect might influence the renovation stages of the building, what materials and strategies are suggested and when the measures will be carried out.

To make policy pathway 3 possible, the EU and its Member States must support it through a number of enabling actions.

Immediate actions

- Collecting and storing information on buildings' life-cycle emissions, based on a common operational standard is needed and would increase transparency and awareness about embodied carbon. The life-cycle information should be compiled in a publicly available database, starting with public and new buildings.
- Introducing a whole-life carbon performance indication in the EPC and their renovation recommendations. The EPBD already makes it possible to the Member States to express the building performance using indicators additional to primary energy. One indicator could be whole-life carbon using a light LCA approach.
- Introducing and continuing the development of building renovation passports and digital building logbooks – these are an important link to enable whole-life

[107] The EU Level(s) framework is a protocol that brings together all relevant standards on whole-life carbon (and other aspects). The framework could be evolved to enable benchmarking of the whole-life carbon performance and thus support this policy pathway. The European Standard [EN 15978] specifies the calculation method, based on LCA and other quantified environmental information, to assess the environmental performance of a building, and gives the means for the reporting and communication of the outcome of the assessment. Several other European and ISO standards do address whole-life carbon and sustainability of buildings. See compilation in Bionova Ltd (2018) The Embodied Carbon Review (Available: Online). While most existing whole-life carbon-standards are considered too "high-level" by industry professional, some are already considered operational and commonly used, one example is RICS (2017) RICS professional statement: Whole life carbon assessment for the built environment. (Available: Online).

[108] Sweden is currently introducing a climate declaration requirement for new constructions, which will enter into force on 1 January 2022 (see link). It includes "developing a national database containing climate data and taking measures to promote carefully-considered requirement specifications from a life-cycle perspective". Databases like this are needed to support the inclusion of whole-life carbon considerations in new buildings and renovatin of existing buildings.

[109] A digital building logbook is a common repository for all relevant building data. It facilitates transparency, trust, informed decision making and information sharing within the construction sector, between building owners and occupants, financial institutions and public authorities.

[110] A Building Renovation Passport is defined as a document outlining a long-term step-by-step renovation roadmap for a specific building, resulting from an on-site energy audit and fulfilling specific quality criteria and indicators established in dialogue with building owners. As the passport is based on a detailed energy audit it is well placed to integrate LCA considerations. See European Commission's Technical study on the possible introduction of optional building renovation passports (see link)

carbon assessments and informed decision-making and could store all the relevant life-cycle building data.
- Introducing LCA reporting requirements for larger public buildings and new constructions
- Significant investments in skills, communication, financial support and good practice forums, as described under policy pathway 1.

Subsequent actions

- Exploring how LCA and related validation/compliance can be included cost-effectively. Pilot cases can help testing and validation of the approach.
- Continuing the development of Level(s)[111] which is based on established LCA assessment tools and, implicitly, whole-life carbon.
- Introducing LCA reporting requirements for all buildings in connection with EPC

Existing cases to learn from:

No existing case is currently integrating whole-life carbon considerations.

Pros	Cons
+ Takes whole-life carbon into account and thereby contributes further to the national carbon reduction targets + LCA will steer the market towards more sustainable options, resulting in wider benefits	-Setting up the whole-life carbon data infrastructure will require time and considerable investments - Requires considerable revisions of the existing regulatory framework - More difficult for homeowners to grasp and more difficult to communicate broadly - Technically and administratively more complex - Require additional training for energy experts and construction professionals

[111] Level(s) is a common European approach to assess and report on the sustainability of buildings.

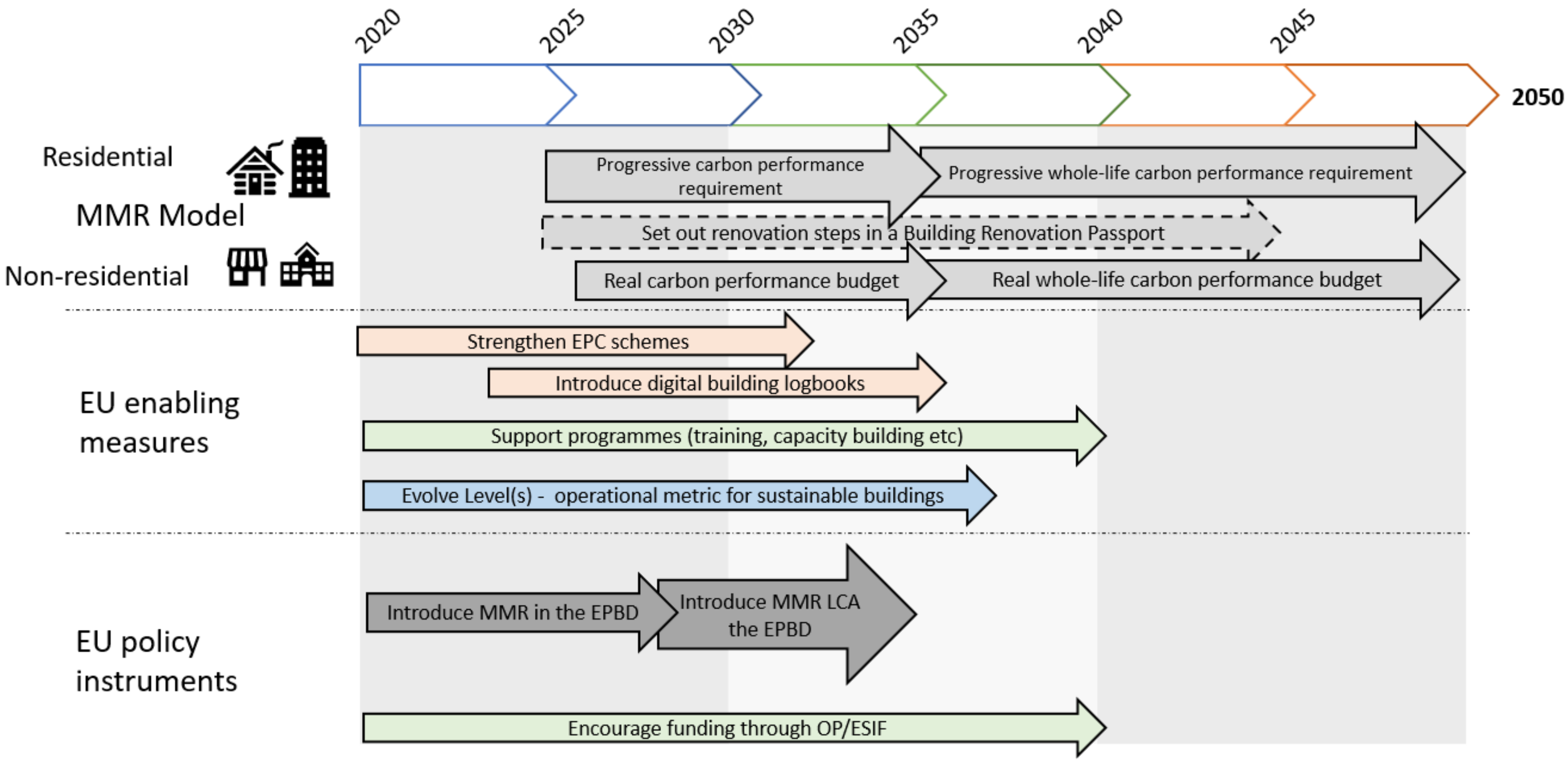


Figure 17: Policy pathway 3 - Timeline

5.4. Policy pathway 4: Moving all buildings towards the objective of a decarbonised building stock by 2050

The focus of the policy pathway 4 is to capture the key trigger points in a building's lifetime in addition to progressive enforcement of minimum requirements. The pathway goes beyond tackling just the worst-performing buildings, as it applies to 97% of all buildings[112]. Trigger renovation concerning property transfers could foster an effective and smooth transition towards the 2050 objective. The additional cost for the property buyer to upgrade the building's EPC label with 1-2 steps, will amount to a fraction, on average, of the cost of buying the property, which can be incorporated in the total cost. Prospective building owners would be made aware of this requirement and can thus plan accordingly. A link with energy efficiency mortgages[113] could reduce the extra financial burden of this requirement.

Policy pathway 4 combines two MMR models:

1. The first sets a renovation obligation for all properties that are being sold and does not already have an EPC label A (or what rating is required for the specific building to be compliant with the 2050 requirement).
2. The second sets progressive minimum energy performance requirement for operational energy consumption for all buildings to make sure that all the worst-performing buildings are being upgraded (as in policy pathway 1).

To make policy pathway 4 effective, the EU and its Member States must support it through:

- Updating EPCs and improving the instrument's penetration, reliability and awareness.
- Improving the information available on the real estate market and raise awareness of all stakeholders involved in real estate transactions.
- Investing in skills, communication, financial support, and good practice forums, as described under policy pathway 1.

Existing cases to learn from:

- France: The Energy and Climate Law (Loi 2019-1147), which states that if the building does not meet the minimum standard, at the point of sale or rent, from 2028 (primary energy consumption exceeds 330 kWh/m2/year), an energy audit must be performed which includes suitable renovation measures to meet the minimum standard.

Pros	Cons
+ Boosts the renovation activities + All buildings (except the highest-performing ones) must comply, which can increase the overall acceptance	- Possible negative effect on the housing market, as the buildings would be relatively more expensive with this requirement - Confusing mix of different requirements, challenging to understand and communicate

[112] See BPIE's analysis of EU's building stock based on EPC data, where only 3% of existing buildings have an EPC label A. (Available: Website)

[113] An energy efficient mortgage is a loan product that allows borrowers to reduce their utility bill costs by allowing them to finance the cost of incorporating energy-efficient features into a new purchase. See: the work of the Energy Efficiency Mortgage Initiative (Available: Webiste)

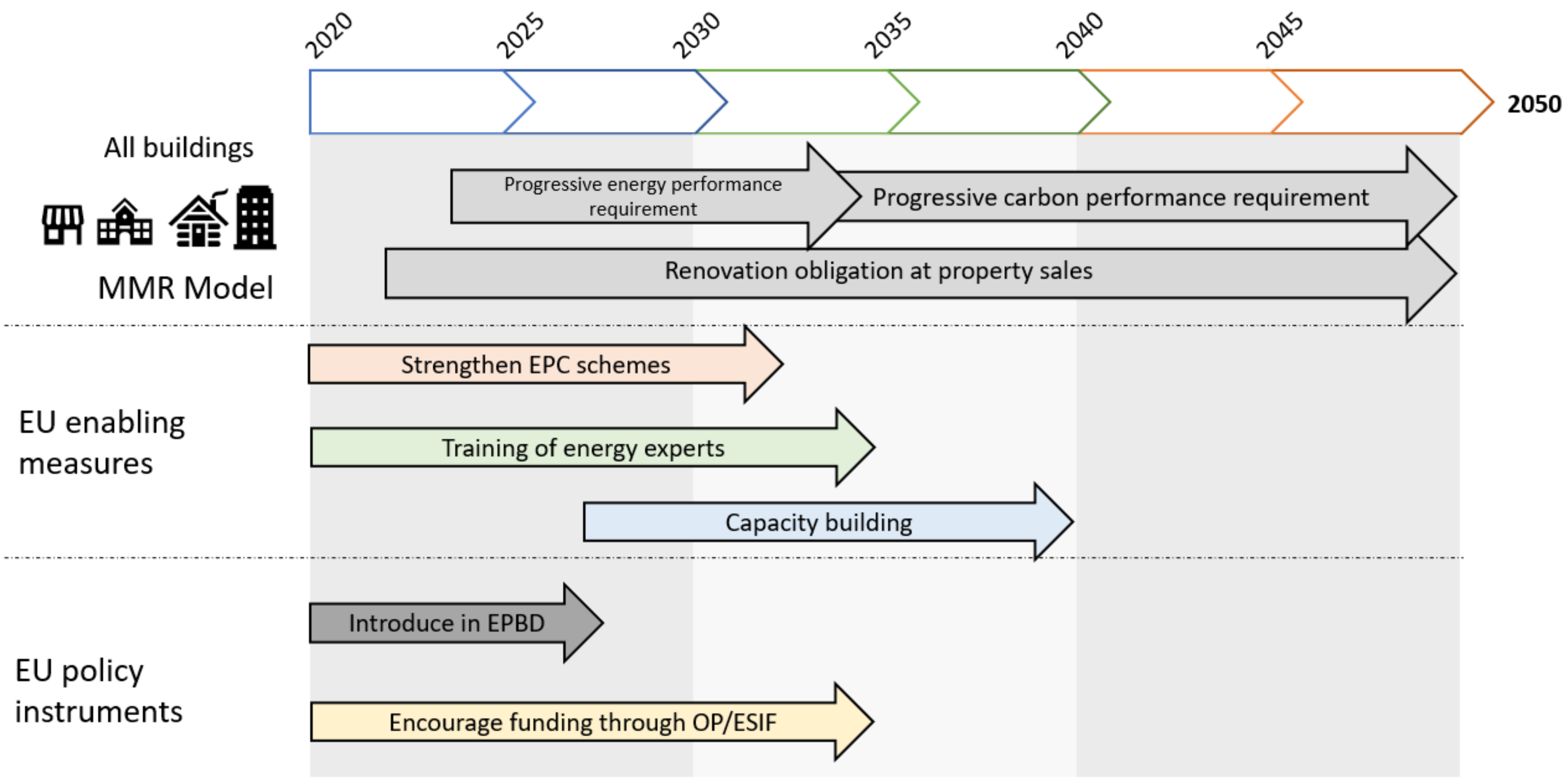


Figure 18: Policy pathway 4 - Timeline

6. STEP 4: IMPACT AND FEASIBILITY DISCUSSION

This chapter summarises the impact and feasibility assessment of different MMR models and identified policy pathways. The chapter first recaps the central EU policy options followed by an impact and feasibility discussion. The subsequent section describes the impact of the identified policy pathways, followed by a section that summarises the impact and feasibility of the MMR models. The sections on impact and feasibility are followed by a short discussion.

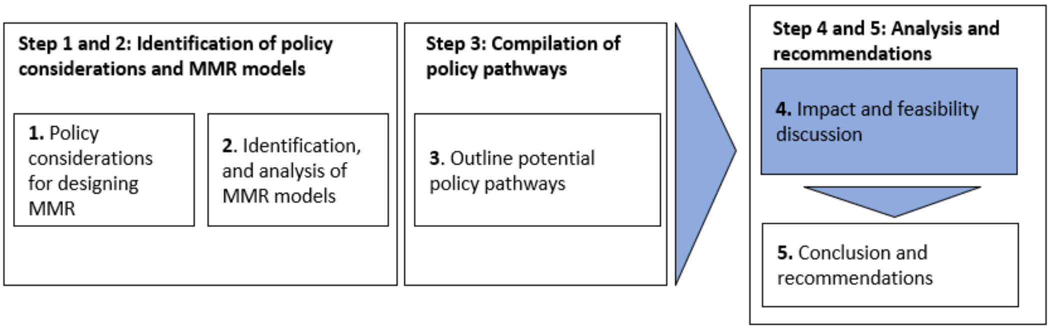


Figure 39. Research flow diagram

6.1. What can the EU do to introduce MMR for existing buildings?

The impact of the MMR depends on how any regulatory requirements will be defined in the EU regulatory framework and, more importantly, how any EU regulatory framework will be transposed and implemented by the Member States. Several broad alternatives exist. The EU could:

- Encourage Member States to implement MMR for existing buildings and support the development of existing cases. The encouragement could, for example, comprise of financial streams dedicated to implementing MMR or strong recommendations based on policy gaps identified in NECP and LTRS.
- Mandate Member States, through the EPBD revision, to implement MMR for their building stock (or parts thereof), while leaving flexibility to the Member States to design the requirement (similar to the EPC regulations).
- Set an energy-saving or renovation obligation for the Member States based on results (as with article 5 or 7 of the EED). MMR could then be one way to achieve this result.

To contribute effectively to the 2050 target, MMR needs to become fully operational in the next 5-7 years, as a later introduction would require a steep and sudden increase of the renovation rate that would be impractical for the construction value-chain to materialise. The implementation date should be carefully balanced between the need for immediate impacts, the need for a well-designed MMR and the readiness of the market.

Regardless of how and when and at what level MMR is introduced, it needs to be supported by a wider policy framework. Many of the supportive measures depend on the local context, but the analysis of existing cases shows that the introduction of MMR must be accompanied by several supportive measures to become feasible.

- Financial support schemes to make the requirement more palatable for key stakeholders, especially the building owners. The review of existing cases shows that the requirement should be accompanied by financial support (grants, low-interest loans) and technical support (such as free energy advice). Financial support could also be used to lessen the additional burden on vulnerable groups and stimulate early compliance. Often a considerable share of the worst-performing building stock is owned/rented by people that are vulnerable to a cost increase. Finally, financial support can incentivise real estate investors and building owners to renovate beyond the minimum requirement and do so earlier rather than later.

- Reliability and usability of the EPC must be improved to enable successful implementation and enforcement of MMR. The EPC schemes, in most Member States, will need to be improved and adjusted for the specific purpose. The Renovation Wave strategy proposes the introduction of the novel instruments of Building Renovation Passports and Digital Building Logbooks, which currently only exist in a few Member States. These instruments could support and strengthen the EPC schemes, by offering better renovation advice and facilitating links to third-parties, such as one-stop-shops.
- Public awareness and acceptance are key for effective implementation of MMR. People should be aware of the requirement itself as well as the purpose and most importantly the benefits behind it. Lessons learnt from existing cases show that it is difficult to get the right information out there. Support can be given to the Member States to carry out tailored communication campaigns and integrated renovation services, such as one-stop-shops, to make the 'renovation journey' smoother.
- Skills in the construction value chain. A skilled workforce is required to realise the renovation boost that will be triggered by MMR. Investments are needed in training and capacity building, to make sure there are enough skilled workers to carry the Renovation Wave when it arrives.

Consistency with subsidiarity and proportionality principles

The EU's ability[114] to decide over the Member States on energy and climate issues is guided by the principles of subsidiarity and proportionality. The subsidiarity principle states that the EU shall act only if and in so far as the objectives of the proposed action cannot be sufficiently achieved by the Member States. This principle thus aims to ensure that decisions are taken as closely as possible to the citizens. The development of integrated common energy and climate policies has been found compliant with this principle, to ensure that the region achieves its agreed objectives. It therefore only seems feasible to have an EU-wide generic MMR provision in respect of subsidiarity and proportionality if it leaves the flexibility to the Member States decide on the details (e.g. the specific performance standard below which it would mandatory to renovate).

The principle of proportionality is twofold. It aims to ensure that the proposed action is capable of attaining the intended objective ('*appropriateness'*) and does not go beyond what is necessary to attain the objective ('*indispensability'*). This means that the proposed action cannot be replaced by an alternative form of action with equal effectiveness, but which would be less far-reaching in terms of the effect on the residual powers of the Member States.

Impact assessments form a key part of the Commission's better regulation agenda, which seeks to design and evaluate EU policies and laws so that they achieve their objectives most efficiently and effectively. The revision of the EPBD will be accompanied by an impact assessment, which is expected to also address the introduction of MEPS.

Property Rights

According to article 17 (1) of the Charter of Fundamental Rights of the European Union (2012/C 326/02), "Everyone has the right to own, use, dispose of and bequeath his or her lawfully acquired possessions. No one may be deprived of his or her possessions, except in the public interest and the cases and under the conditions provided for by law, subject to fair compensation being paid in good time for their loss." It further states

[114] The EU's ability to take action on energy and energy efficiency issues is enshrined in Article 194 of the Treaty on the Functioning of the European Union

that "The use of property may be regulated by law in so far as is necessary for the general interest."

The introduction of an MMR will not deprive any property owner of his or her building. In line with many stakeholders' view, apart from allowing sufficient lead time, it is recommended to provide financial support alongside an MMR scheme, which could partly compensate for financial investments the MMR requires the property owner to make. Financial support is, however, not considered as necessary to allow for intervention under the Charter of Fundamental Rights of the European Union, since more importantly, the introduction of an MMR in the Member States will serve the general interest. MMR is considered as a key instrument to decarbonize the building stock and secure sustainable energy supply to citizens of the European Union addressing one of the most persistent barriers against deep energy renovation, the split incentive dilemma. In addition, the measures will lead to an increase in health and well-being of a significant share of the population and a general increase of the property value, also in view of rising carbon prices.

6.2. Impact of the policy pathways

The policy pathways build on ideas from existing MMR cases, a wider analysis of the EU directives and instruments, as well as stakeholder inputs.[115] As discussed in the previous section, the impact of the policy pathways will, to a large extent, depend on the scope and form of the legal provision. If the MMR is mandated by the EPBD (or another directive) it will be more effective than if MMR comes in the format of best practice exchange and encouragement by the EU. **Table 4** discusses the relative impact of the different models, given their timelines and included MMR models.

Excellent	Good	Moderate	Poor

Policy pathway		Discussion of the potential impact
Policy pathway 1: Progressive minimum energy performance requirement	Good	The potential impact of the pathway based on energy performance requirements is *good*. The pathway utilises existing infrastructure (i.e. EPC regimes) and directives (i.e. EPBD), which could make the required preparation time shorter and communication easier. The sole focus on energy performance will reduce the energy need in buildings but might not necessarily result in the required carbon emission reductions due to the "rebound effect" (i.e. performance gap). The EU can mitigate these adverse effects by researching how the performance gap can be alleviated and with other measures supporting the uptake of renewable energy sources. Triggering partial renovations, without the support of a BRP, there is a risk that MMR will lock out future cost-optimal measures.[116]
Policy pathway 2: Progressive minimum carbon	Excellent	The estimated impact of the pathway based on carbon performance requirements is *excellent*. The scope focuses on the carbon emissions stemming from the use of the

[115] The stakeholder input includes the results of the online survey and the workshop on 14 May, at which 94 stakeholders participated. A few stakeholders have also shared their statements in a bilateral correspondence with the consortium.
[116] This will rarely by the case with incremental improvements of the worst-performing buildings, such as when improving the building from an EPC F to an EPC E. For the building to become a low-energy building, the renovation sequence ought to planned as early as possible.

performance requirement		building. The pathway requires a more substantial modification of the existing infrastructure (i.e. EPC regimes) and directives (especially EPBD and Renewable Energy Directive (RED)), which will cause a longer starting distance. The pathway assumes higher carbon reductions than the first pathway because of the shift in metrics of the requirement, from energy to carbon performance. The performance gap will remain a barrier. The triggered measures will directly aim to reduce the carbon footprint of the building. As with pathway 1, without the support of a BRP, there is a risk that the MMR will lock out future cost-optimal measures.[117]
Policy pathway 3: Progressive minimum carbon performance requirement, considering the whole-life carbon footprint		The projected impact from the pathway based on whole-life carbon requirements is *excellent*. The scope focuses on all carbon emission stemming from the whole life-cycle of the building. The pathway requires a very substantial modification of the underlying logic of the existing infrastructure (i.e. EPC regimes), directives (especially EPBD, RED, Waste Framework Directive) and operational whole-life carbon standard (e.g. built on Level(s)), which will cause a longer starting distance, exacerbated also by e.g. data and methodological gaps, delaying the impact. The pathway assumes economy-wide carbon reductions because all carbon emissions are integrated into the requirement. A whole-life carbon standard trigger circularity as a key principle and would tend to favour the reuse of buildings and their materials as much as possible, and influence design decisions in both renovations and new constructions. Finally, the requirement would send a very strong signal to the construction value chain to improve resource efficiency and adopt climate-friendly processes.
Policy Pathway 4: Moving all buildings towards the objective of a decarbonised building stock by 2050		The estimated impact of the pathway focusing on trigger points is *good*. The pathway requires adjustments of the existing infrastructure (i.e. EPC regimes) and directives (especially EPBD and RED), which will cause a longer starting distance. The renovation obligation at property transfer for all buildings, except the ones already complying with the long-term objective, would trigger additional renovation works. The impact assessment of MMR model 6 indicates that adding a renovation obligation to a progressive timeline, as suggested in this pathway, will increase the final energy reductions with 6% and 8% on top of the savings made by the progressive minimum requirement model.

Table 11. Overview of the impact of policy packages

[117] This will rarely by the case with incremental improvements of the worst-performing buildings, such as when improving the building from an EPC F to an EPC E. For the building to become a low-energy building, the renovation sequence ought to planned as early as possible.

6.3. Feasibility of the policy pathways

The feasibility assessment comprises an analysis of the possibility for the EU to introduce this specific pathway, including how it can be incorporated and operationalised based on existing directives, as well as how it complies with the subsidiarity and proportionality principles. The assessment does also reflect how easily it can be implemented by the Member States, including its applicability to existing instruments, simplicity of the suggested MMR and its ease of compliance.

The feasibility of the first pathway is the highest, which foresees progressive minimum energy performance requirement, as it is a practical and natural evolution of the existing policy framework, including the EPC and LTRS. The other pathways require more substantial work, both in terms of legislative developments and improving and setting up supporting structures and frameworks. As indicated at the beginning of this chapter, the political feasibility will depend on the stringency of the provision and which supporting measures accompany the provision. **Table 5** summarises the key points.

Excellent	Good	Moderate	Poor

Policy pathway		Discussion of the feasibility
Policy pathway 1: Progressive minimum energy performance requirement		The feasibility is *good*. The EU can introduce a general obligation while leaving flexibility to the Member States to decide on exact implementation. The MMR model suggested in the pathway would be a natural extension of the current EPBD. The EPC schemes will have to be improved across the EU, in terms of reliability of the ratings and their availability. Most countries EPC databases must also be updated to ensure it can be used to check compliance with the minimum standard.
Policy pathway 2: Progressive minimum carbon performance requirement		The feasibility is *moderate*. The EU can introduce a general obligation while leaving flexibility to the Member States to decide on exact implementation. The carbon-oriented pathway would change in the scope of the EPBD and shift focus from primary energy to carbon. The revision of Article 11 of the EPBD could introduce a requirement to also measure and display the operational carbon emission level, which then could be used in the MMR. As with Pathway 1, the EPC schemes will have to be improved across the EU, in terms of reliability of the ratings and their availability. Most countries EPC databases must also be updated to ensure it can be used to check compliance with the minimum standard.
Policy pathway 3: Progressive minimum carbon performance requirement, considering the whole-life carbon footprint		The feasibility is *moderate*. The EU can introduce a general obligation while leaving flexibility to the Member States to decide on exact implementation. The whole-life carbon-oriented pathway would require changes in the scope of the EPBD. The first step would require public authorities and the construction value-chain to start collecting data to this end through e.g. a common standard. An MMR linked to carbon emissions can better align the requirement with the long-term climate objectives, yet is much more complex to design and put

		in practice, because there is no common standard[118] for how data can be gathered and stored, and no database of whole-life carbon data[119] that can be used for benchmarking purposes.). The proposed introduction of Digital Building Logbooks, could together with the Level(s) framework and Construction Product Declaration, comprise and carry the required information related to embodied carbon. Yet, these frameworks are still novel and would require a substantial preparation time, which is foreseen in the pathway timeline. Energy experts and auditors would need the training to be able to consider the whole-life carbon impact in their EPC/BRP recommendations.
Policy Pathway 4: Moving all buildings towards the objective of a decarbonised building stock by 2050		The feasibility is *moderate*. The EU can introduce a general obligation while leaving flexibility to the Member States to decide on exact implementation. MMR based on property transfers could face difficult acceptance among stakeholders. At the same time, if the requirement applies to almost all building owners, people will perceive it as more 'fair' as everyone will have to contribute to the common goal of mitigating climate change through energy renovations. The enabling infrastructure is already in place on most MS. Most local authorities have registries of property owners in their jurisdictions, which in many regions are obliged to pay property tax (and/or property purchase tax). As with Pathway 1, the EPC schemes will have to be improved across the EU, in terms of reliability of the ratings and their availability. Most countries EPC databases must also be updated to ensure it can be used to check compliance with the minimum standard.

Table 12. Overview of the feasibility of policy pathways

[118] The EU Level(s) framework is a protocol that brings together all relevant standards on whole-life carbon (and other aspects). The framework could be evolved to enable benchmarking of the whole-life carbon performance and thus support this policy pathway. The European Standard [EN 15978] specifies the calculation method, based on LCA and other quantified environmental information, to assess the environmental performance of a building, and gives the means for the reporting and communication of the outcome of the assessment. Several other European and ISO standards do address whole-life carbon and sustainability of buildings. See compilation in Bionova Ltd (2018) The Embodied Carbon Review.

[119] Sweden is currently introducing a climate declaration requirement for new constructions, which will enter into force on 1 January 2022 (Available: Website). It includes "developing a national database containing climate data and taking measures to promote carefully-considered requirement specifications from a life-cycle perspective". Databases like this are needed to support the inclusion of whole-life carbon considerations in new buildings and renovatin of existing buildings.

7. STEP 5: CONCLUSION

The decarbonisation of the European building stock needs a considerable boost to meet the net-zero ambition by 2050. The improvement of existing buildings remains slow, with a renovation rate that lingers at 1%, while the deep renovation rate is only around 0.2%.[120] There are many reasons for these low rates, including low energy prices, split incentives, the current capacity of the construction value chain, the ambiguous link between the building's performance and the real estate value, and the lack of awareness of the benefits stemming from energy renovations.

This closing chapter summarises the main findings of this report.

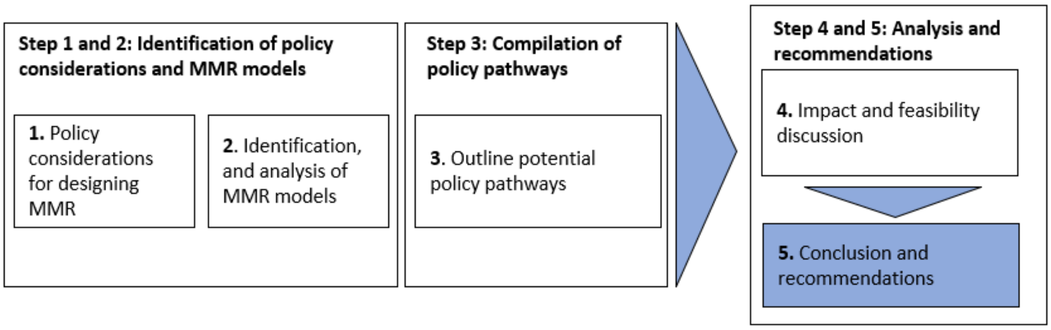


Figure 40: Research flow diagram – Step 5

All EU countries must establish LTRS to support the renovation of their national building stock into a highly energy-efficient and decarbonised building stock by 2050, including milestones for 2030, 2040 and 2050. The LTRS must include, among other things, an overview of the national building stock, and policies and actions to stimulate cost-effective deep renovation of buildings and to target the worst-performing segments. The recently submitted LTRS and the national energy and climate plans might confirm that the new and planned measures are not enough to be on track for the 2050 objectives.[121] This shows the need for better implementation of existing policies and measures along with introducing more stringent policies and measures to meet the 2050 target, including MMR for existing buildings.

The analysis in this report shows that, if designed properly and embedded in a wider policy framework, MMR can overcome many of the barriers the renovation market is facing, including lack of interest in energy renovations, insufficient awareness of energy-saving potential and the split-incentives dilemma.

All the MMR models would have a considerable impact on the European building stock.

- Introducing a progressive minimum energy performance requirement would trigger the renovation of the worst-performing buildings and send a clear signal to the real estate market. Not aligning the underlying with operational carbon use or whole-life carbon, risk some suboptimal investments if the main objective of this policy tool is to reduce carbon emissions.
- Introducing a progressive minimum carbon performance requirement would better align with the long-term climate objectives, which are expressed in carbon emission levels. This MMR can drive increased demand for renovations,

[120] Ipsos & Navigant (2019) Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU. European Commission. (Available: Online)
[121] See review of the first 12 LTRS by BPIE (2020) A review of EU Member States' 2020 Long-term Renovation Strategies. (Available: Online)

with an optimal balance between energy efficiency and renewable energy investments.

- Introducing a progressive minimum carbon performance requirement, considering whole-life carbon aspects, would have the potential to get all carbon emissions down to zero by 2050 by integrating all related emissions. Yet, this MMR is more complex to design and put in practice. This MMR would require a decisive and concerted effort between different ongoing policy initiatives supporting the circular economy. It would moreover necessitate public authorities in MS and the construction value-chain to start collecting data. A whole-life carbon standard would tend to favour the reuse of buildings and their materials as much as possible, and influence design decisions in both renovations and new constructions.
- Moving all buildings towards the objective of a decarbonised building stock by 2050 by capturing the key trigger points in a building's lifetime in addition to progressive enforcement of minimum requirements. The MMR goes beyond tackling just the worst-performing buildings, as it applies to 97% of all buildings.

MMR for existing buildings is also being implemented around Europe and the United States and described as a policy tool with the potential to increase the renovation rate. The UK, France, the Netherlands and two regions in Belgium (Flanders and Brussels) have implemented or are planning to implement MMR for existing buildings to improve the quality of the worst-performing buildings. In France and Flanders, their 2050 targets drive the introduction and implementation of MMR as part of the delivery mechanism. MMR for existing buildings is also gaining ground in the United States, with several cities and municipalities implementing carbon emission limits for certain buildings.

The EPC framework is the most obvious reference point for introducing MMR for existing buildings. The purpose of the EPC is to provide information on a building's energy performance status and to offer suggestions for cost-effective improvements, while less suited for considering whole-life carbon aspects at present. On an aggregate level, they offer information about the building stock and how it can be decarbonised. The comparability of EPCs across the EU (in terms of aspects like calculations, control and data availability) needs further improvement. EPCs already have a link to voluntary carbon metrics, where a change in the main scope would require additional legislative efforts, in addition to the significant reinforcement and harmonisation already planned in the Renovation Wave strategy.

Alternatively, MMR can be linked to real energy consumption or climate footprint, which can be derived through smart meters and/or utility bills. The MMR can also be defined as a renovation obligation linked to specific trigger points, such as property transfers or non-energy renovation works, which is not reliant on the standard of the building. The most effective MMR policy packages combine an enforcement calendar (i.e. the requirement is set by a specific year and enforced according to a defined timeframe) with specific trigger points.

Development since the EPBD Impact Assessment [SWD(2016) 414 final]

The potential and feasibility of MMR for existing buildings (Measure 1B: Oblige the renovation of buildings to reach a given standard before transactions), was evaluated in 2016 EPBD Impact Assessment. While viewed as effective in increasing the renovation rate and in reducing energy poverty, an MMR was considered not feasible due to "uncertain impact on the real estate market and probably stepping out of subsidiarity and proportionality limits of EU intervention". It was also noted that "detailed statistical data on national building stocks, linked with socio-economic indicators is a precondition for setting obligations on building renovation; however, this data is currently not available.".

The identified issues remain in place and have been discussed in this report. Below is a summary of these considerations.

1. The impact on the real estate market remains uncertain but the lessons learned we can draw at this point, suggest the impact will be positive. In the Netherlands, a significant increase of investments in renovation works of commercial properties has already been observed in anticipation of the regulation scheduled to come into force in 2023, which requires office buildings to have an EPC of C. Furthermore, MMR will also provide a clear signal to the market that non-compliant assets are at risk of value depreciation or becoming stranded assets. Having a clearer value differentiation and implicitly, a stronger link between energy performance and property value will help improving the business case and decision marking for investing in renovations.
2. The issue of subsidiarity and proportionality will depend on how the MMR is regulated and enforced by the EU. An uniform design risks departing from the subsidiarity and proportionality principles and not capturing local context and needs. The experts consulted in this study, do not see the issue of subsidiarity and proportionality as major obstacle, if the MMR principle is established and enforced through the EPBD, and then designed and implemented by the Member States within certain defined boundaries. While a one-size-fits-all approach is in all likelihood not possible, the EU and its Member States should strive for as much harmonisation as possible because the signal to the real estate market would be stronger and more unambiguous, while also increasing synergies and learnings across borders.
3. The lack of reliable and granular data of the building stock is still a large obstacle. Most Member States rely on the EPC databases for information about their building stock, while few databases have been designed for this purpose. Since 2016, a large number of advanced EPC databases have appeared and evolved (e.g. Denmark and Ireland), together with digital building logbooks (Woningpas in Flanders and Casa+ in Portugal), material passports (Madaster in the Netherlands and Basta in Sweden) and a whole-life carbon database (Climate declaration database in Sweden). The Renovation Wave strategy set out to further improve the EPC databases and introduce digital building logbooks, which are needed to underpin the introduction of an MMR.

Potential impacts on the real estate market

MMR can have significant effects on shaping business models and investment decisions in the real estate sector.

First, the introduction of MMR will mean that real estate managers and practitioners will have to consider the performance of buildings and find it easier to draw up decarbonisation strategies, identify reliable targets and actions to improve performance, as well as communicate and demonstrate compliance with MMR in a consistent way.

Certainty around MMR makes the business case of investing in energy efficiency improvements more compelling.

Second, MMR will incentivise property markets to differentiate according to energy performance and will likely make the link between energy performance and market value (or investment worth) more visible and direct. In this sense, MMR can contribute to a price correction to reflect the performance of the building and/or affect the cash flow of non-compliant stock. Such effects are seen as beneficial because energy performance is not yet adequately reflected in property valuations, investment and financing decisions, as well as the by real estate markets in general.

MMRs are primarily aimed at increasing the rate of upgrades to existing inefficient properties and raise awareness of energy-related issues. In the Netherlands, a significant increase of investments in renovation works of commercial properties has already been observed in anticipation of the regulation – which requires office buildings to have an EPC of C – scheduled to come into force in 2023. On the other end, MMR will also provide a clear signal to the market that non-compliant assets are at risk of value depreciation or becoming stranded assets. Real estate investors and landlords may discriminate against buildings with low ratings within their portfolio strategies and seek to divest of stock that is either at risk or fails to meet the MMR standards. Others might acquire non-compliant properties and bring them up to standard if this is economically feasible. Properties in prime locations are less likely to be affected negatively in value terms by MMR, but all properties of poor specification and energy efficiency, which are expensive to upgrade, may reduce in value.

Third, beyond the changing market preferences, lenders, investors and insurers may also start factoring in the risk implications of MMR. This can take the form of either preferential financing conditions for better performing assets or limited access to financing if they do not meet MMRs. If better-performing properties can attract cheaper financing, this could positively impact the value of such properties. Conversely, if financing and insuring sub-standard properties become more difficult or more expensive, it could negatively impact their market value.

The introduction of an MMR scheme is not regarded as counteracting article 17 (1) of the Charter of Fundamental Rights of the European Union (2012/C 326/02) on property rights. The introduction of an MMR will not deprive any property owner of his or her building. It rather serves the general interest since MMR are considered as a key instrument to decarbonize the building stock and secure sustainable energy supply to citizens of the European Union. In addition, the measures will lead to an increase in health and well-being of a significant share of the population and general increase of the property value, especially in view of rising carbon prices.

Social implications

The MMR has the potential to contribute to ensuring decent homes and a bearable energy bill for Europeans, by alleviating the worst-performing dwellings. 34 million households (or 13.90% of the population) are living in inadequate dwellings throughout the EU, defined as dwellings with leaking roofs, damp walls, etc[122]. These buildings correlate strongly with the worst-performing buildings, which in addition to the health issues comes with high energy costs for the tenants. Renovating these buildings would reduce energy poverty levels as well as related health-care costs.

At the same time, policymakers need to consider the financial burden that comes with an MMR, as many landlords and private building owners may struggle to cover the extra cost. Therefore, affordability of renovations and prevention of energy poverty should be

[122] See EU's Energy Poverty Observatory (Available: Website)

guaranteed by an enabling framework with financial measures for building owners and residents, especially the most vulnerable ones.

The landlords should be able to recoup the renovation investments through an increase in the rent which corresponds to the energy costs saved by the tenants.

Key lessons learned

MMR is a powerful tool to address both the low rate and depth of renovations. Experiences from the Member States with MMR already in place provide useful lessons for the future design of the instrument, which can be tailored to the different segments of the building stock and ownership tenures. Coupled with adequate financial support, MMR can contribute to decent homes for the more vulnerable.

- **A clear overview of the building stock is the starting point to design effective MMR**. This includes, for example, having a comprehensive understanding of the energy and climate performance of the building stock, particularly the worst-performing buildings, the different tenure statuses as well as of the different building typologies, to which the obligation will apply. Ideally, MMR is linked to already established frameworks, like the EPCs in Europe or the Energy Star Portfolio Management tool in the USA.
- An effective MMR needs to be embedded in a **wider policy framework**, including adequate and targeted financial support, capacity building and information measures.
- **EPC schemes need to improve** to be able to effectively facilitate an MMR built around them, including their reliability, comparability, availability as well as data gathering and the functionality of EPC databases.
- While MMR is introduced to improve the worst-performing buildings, **voluntary standards** can be defined up to the 2050-standard (e.g. a net-zero carbon building) and linked with additional financial support to incentivise investments in the highest performing buildings. The MMR can then be progressively tightened over time until the 2050-standard has been reached.
- **Different building types can be treated differently within the MMR scheme**. Larger, non-residential or public buildings could lead by example by having to comply with the MMR before other building typologies. The MMR for these buildings could also be stricter and/or more sophistically elaborated, as better data gathering opportunities and more granular data generally exist.
- Special attention must be paid to **vulnerable citizens** who live in inadequate dwellings to make sure they are not "punished" twice. The risk of "renovictions", where people cannot afford to pay their rent, due to rent increases after renovations should be evaluated and addressed by an appropriate supporting framework, such as targeted financial support and a legal framework that forbids disproportionate rent increases.
- **Stakeholder involvement is essential** from the very early stages in the design of an MMR and to build understanding, support and acceptance around the policy. Policymakers can gather valuable insights and tailor MMR design choices to the characteristics of local buildings, different tenures, and the built environment.
- Communicate on **multiple benefits** of energy renovations (beyond carbon and energy), such as better comfort, health, productivity, and overall wellbeing.
- Gradually including **carbon performance** and **embodied carbon metrics** can contribute significantly to achieving GHG emission reductions, though at the short term challenges remain concerning data gathering and benchmarking.
- **The MMR ought to be coupled with tailored renovation advice** (such as a building renovation passport) to avoid technical and economical lock-in effects.
- Ensure **sufficient lead time** and **administrative capacity** to design and implement MMR. The public authorities must show that they are serious with the enforcement but also give the market leading time to adapt.

- **The policy design should be aimed at simplicity**. Too complex regulation, such as many different cases and exemptions, may make the MMR enforcement less likely to succeed.

8. REFERENCES

Bionova Ltd (2018) The Embodied Carbon Review. (Available: Online)

BPIE (2018). "The Inner Value of a Building". (Available: Online)

BPIE (2020) A review of EU Member States' 2020 Long-Term Renovation Strategies. (Available: Online)

BPIE & I2-4C (2016). "Driving Transformational Change in the Construction Value Chain". (Available: Online)

Buildings2030 & BPIE (2018). "Quantifying the impact of a better indoor environment in schools, offices and hospitals". (Available: Online)

C40 (2019) "How to set energy efficiency standards for existing buildings". C40 Cities Climate Leadership Group. (Available: Website)

ECSO. (2020). "Analytical report. Improving the human capital basis". European Commission - European Construction Sector Observatory. (Available: Online)

Economidou M (2018). "Energy efficiency upgrades in multi-owner residential buildings - Review of governance and legal issues in 7 EU Member States". European Commission Joint Research Centre. (Available: Online)

Energy Saving Trust. (2011). "A convenient truth – Promoting energy efficiency in the home". (Available: Online)

Entranze Project. Policies to Enforce the Transition to Nearly Zero Energy Buildings in the EU. European Commission - Intelligent Energy Europe programme. (Available: Website)

European Commission (2016) Impact Assessment of the EPBD 2016, [SWD (2016) 414 final] (Available: Online)

European Framework for Action on Cultural Heritage. (2018). European Union. (Available: Online)

European Climate Foundation. (2020). "Zero Carbon Buildings 2050". Modelling by Climact based on EU Calc data. (Available: Online)

EUCalc (2020) Long-Term Renovation Strategies: How the building sector can contribute to climate neutrality in the EU. European Commission – Horizon 2020 project. (Available: Online)

EU Technical Expert Group on Sustainable Finance (2020). "Technical annex to the TEG final report on the EU taxonomy". (Available: Online)

Fabbri, M; Volt, Jonathan; Zuhaib, S; (2020). "Final report – Technical study on the possible introduction of optional building renovation passports". European Commission. (Available: Online)

Fawcett & Topouzi. (2020). "Residential retrofit in the climate emergency: the role of metrics". Buildings and Cities. (Available: Online).

Government of Flanders (2018). "Ontwerp Vlaams Energieplan". (Available: Website)

Hinge (2020) International Review of Minimum Energy Standards for Rented Properties/ Available: Online)

Historic Environment Scotland. (2020). "Climate Action Plan 2020-25". (Available: Online)

Ipsos & Navigant (2019) Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU. European Commission. (Available: Online)

Nadel, S & Hinge A (2020) Mandatory Building Performance Standards: A Key Policy for Achieving Climate Goals. ACEEE (Available: Online)

RICS (2017) RICS professional statement: Whole life carbon assessment for the built environment. (Available: Online).

RSM. (2019). "Enforcing the Enhancement of Energy Efficiency Regulations in the English Private Rented Sector. (Available: Online)

Pehnt, M; Weiß, U; Fritz, S; Jessing, D; Bürger, V; Kenkmann, T; Lambrecht, K & Steinbach, J (2019) Evaluating the renewable heating and efficiency obligation for existing buildings –

insights into the mechanisms of mandatory building requirements. ECEEE summer study. (Available: Online)

Röck, M; Ruschi, M; Saade, M;Balouktsi. M; Nygaard Rasmussen, F; Birgisdottir, H; Frischknecht, R; Habert, G & Passer, A . (2020). 'Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation'. Applied Energy. (Available: Online)

Sayce, S & Marji Houssain, S. (2020). "Minimum Energy Efficiency Standards (MEES): one year on: A Progress Report". (Available: Online)

Stefan. T; Suerkemper, F; Adisorn,T; Hauptstock, D; Schäfersparenberg, C; Tholen, L; Vondung, F; Becker, D; Tesniere, L; Bourgault, C & Förster, C (2016). "Energy Efficiency Policies in Europe: Danish Building Code – Denmark". (Available: Online)

Sunderland, L & Santini, M (2020). "Filling the policy gap: Minimum energy performance standards for European buildings". Regulatory Assistance Project (Available: Online)

Volt, J & Toth, Z (2020). "Definition of the Digital Building Logbook". European Commission. (Available: Online)

World Green Building Council (2019) Bringing Embodied Carbon Upfront. (Available: Online)

X-tendo (2020) Energy Performance Certificates – Assessing their status and potential. European Commission – Horizon 2020 project. (Available: Online)

9. APPENDIX 1: CASE STUDIES

9.1.1. Europe

In Europe, the adoption of the EPBD has resulted in the implementation of requirements related to EPCs in the various EU Member States and minimum requirements for major renovations and new buildings. Some countries have implemented MMR going beyond what the EPBD requires. Examples of such cases are France, the Netherlands, Belgium, and the UK (see Table 13). Figure 41 indicates the type of compliance applicable in the different Member States.

The metric used for the standards in many cases relates to a minimum EPC rating, a theoretical calculation known as 'asset rating'. In certain regions, e.g. Brussels and France, examples exist that focus on the measured energy, known as 'operational rating'. The building segments targeted by these MMR regimes are diverse, including both residential and non-residential buildings. Compliance is based on compliance cycles, trigger points like sale or renovation, and, in the case of Brussels, building renovation passports.

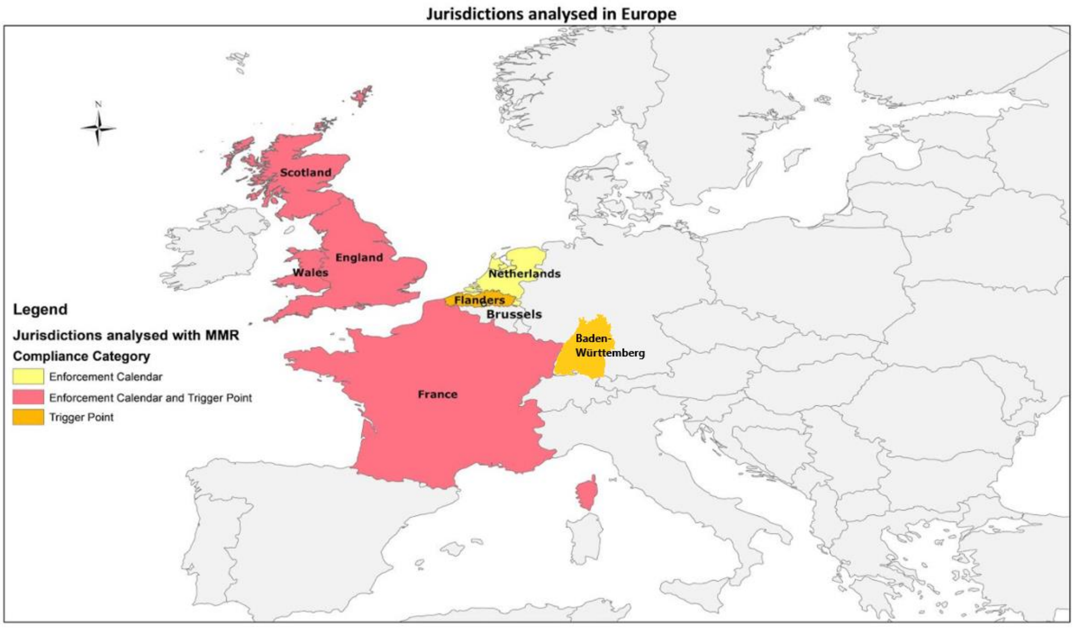


Figure 41. Overview of type of compliance in cases analysed in Europe

Name/description of requirement	Location	Building type	Metric	Effective/ Enforced	Compliance category
Mandatory progressive implementation of a renovation roadmap	Brussels, Belgium	Residential	Asset rating	2030	Building renovation passport
Mandatory energy consumption reductions (PLAGE)	Brussels, Belgium	Non-residential	Operational rating	2019	Enforcement calendar
Minimum energy performance standard for all tertiary buildings[123]	Flanders, Belgium	Non-residential	Asset rating*	2030	Change of owner
Minimum energy performance standard for residential buildings	Flanders, Belgium	Residential	Asset rating	2021	Change of owner
Minimum quality standards for basic comfort, safety and health	Flanders, Belgium	Residential	Asset rating	2021	Complaints by tenants
Travaux embarqués (embedded work)	France	All	n/a	2017	Implementation of other works
Minimum energy standard	France	Residential	Asset rating	2028	Enforcement calendar/ change in tenancy
Tertiary Renovation Decree	France	Non-residential	Operational rating	2030	Enforcement calendar
Minimum Energy Efficiency Standard	England and Wales	Residential	Asset rating	2018	Change in tenancy/Enforcement calendar
Minimum Energy Efficiency Standard	England and Wales	Non-Residential	Asset rating	2018	Change in tenancy/Enforcement calendar
Minimum Energy Efficiency Standard	Scotland	Residential	Asset rating	2020	Change in tenancy/Enforcement calendar
Minimum standard for all office buildings	Netherlands	Non-residential	Asset rating	2023	Enforcement calendar
Renewable heating and efficiency obligation	Germany, Baden Württemberg	Residential and most non-residential	Asset rating	2008 (with updates 2015)	Trigger point (heating system)

Table 13. Overview of MMR cases analysed in Europe

The following section presents five of the most interesting and representative MMR cases in Europe. A selection criterion was that the cases should go beyond the requirements set in the EPBD.

[123] All non-residential and non-industrial buildings.

Mandatory progressive implementation of a building renovation passport

Brussels, Belgium

The scheme is being developed to improve the energy efficiency of the capital's non-residential buildings and meet international climate goals, especially the 2030 climate objectives of the EU. The vision has been translated into concrete objectives in a strategy document, which was adopted by the Brussels government in 2016 and aims to reduce GHG emissions by 30% by 2025.[124] The Brussels LTRS also includes references to renovation requirements from 2030 onwards based on specified time intervals linked to a building renovation passport (BRP).[125]

Status: Planned.

Legal provision

The scheme aims to reduce the primary energy consumption (kWh/m²/year) of the non-residential building stock. Targeted building owners must propose a three-year action plan to reduce primary energy consumption. The mandated renovations are based on cost-effective measures defined by the local administration, which the building owner refers to in the action plan. The energy reduction in the plan is mandatory and applies to the total building stock owned. The owners decide which measures to apply.

The scheme operates in five-year cycles. The first year is used to formulate the plan, while the subsequent four years are used to execute the plan. The plan is based on 'Energy Performance Certificates 3.0'. These are based on, amongst other factors, thermal insulation, airtightness and heating installations, and thus an asset rating.

Building typology

The programme applies to:

Owner-occupiers and landlords (residential and service sector)

Compliance mechanisms

At the end of every five-year cycle, the execution of the plans is verified by the Brussels Environment Office. If the procedures are deemed non-compliant, sanctions are applicable including administrative fines.

Key success factors

- Proper training for inspectors.
- Cost-effective measures are mandatory and will quickly be implemented. This is good for efficiency but discourages the uptake of less cost-effective measures in investment packages.
- A regulation or scheme fostering the re-investment of the cost-savings from lower primary energy consumption in other energy efficiency measures would enhance the effectiveness but is currently absent.

[124] Second National Energy Efficiency Action Plan Belgium (2011). Belgium.
[125] Strategy to reduce environmental impact of buildings Brussels (2020). Mandatory renovations at 5-year intervals to achieve decarbonisation in 2050. LTRS, p42.

Minimum energy performance standard for all tertiary buildings

Flanders, Belgium

The 2019 Flemish coalition agreement set specific energy efficiency targets as part of Flanders' 2050 goals for the building stock. Within the Draft Flemish Energy plan 2021-2030, the Flemish authorities specify policies to achieve these targets, including energy efficiency measures for the tertiary sector (all non-residential and non-industrial buildings).[126] The rationale behind energy efficiency and more responsible energy usage is to reach European climate targets and reduce energy costs. To achieve this vision, inefficient large non-residential buildings are required to get energy labels and need to be renovated after they are sold.

Status: Planned.

Legal provision

As of 2021, all non-residential buildings are required to undergo a thorough energy renovation within five years after purchase to reduce their climate footprint.[14] From 2025 onwards, all Flemish large non-residential buildings are obliged to have an energy label. After 2030, they also need to reach a minimum energy label (yet to be defined). Public buildings (owned by the government) will need to comply with these measures two years in advance of private building owners.

Building typology

Non-residential buildings (tertiary sector)

Compliance mechanisms

The penalty will probably be monetary fines, but it is yet to be defined.

Key success factors

- The Flanders Energy Agency indicates that this policy is aligned with the long-term goals of carbon neutrality for non-residential buildings.
- The buildings are assessed on actual energy consumption rather than theoretical consumption.
- Transition measures could be considered in the form of no-regret or renewable energy production. Additionally, a requirement for energy audits including obliged implementation of cost-effective measures (like in Brussels) or the adoption of energy management systems could contribute to realising the potential of this policy.

[126] Draft Flemish Energy Plan. (2018). Flemish Government.

Minimum Energy Efficiency Standard in

England and Wales

The Minimum Energy Efficiency Standard (MEES)[127] was introduced in March 2015 by the Energy Efficiency Regulations.[128] The MEES originates from the Energy Act of 2011, which was a package of energy efficiency policies including the now defunded Green Deal. The MEES has been designed to contribute to the legislative targets of reducing CO_2 emissions for all buildings to around zero by 2050.

The MEES is linked to the EPC framework and stipulates that a dwelling cannot be let if it does not comply with EPC rating E. The EPC rating ('SAP rating'), which is the infrastructure used to check compliance, gives a score from 1-100 based on the estimated cost to heat and light the building compared to other buildings of the same size. One of the main reasons for its implementation was to circumvent the split-incentive dilemma, where the landlords are responsible for the building, yet the tenants pay the utility bills.

Status: Ongoing.

Legal provision

From 1 April 2018, the MEES requires private landlords of homes rated at EPC ratings F or G to improve their property to E before issuing a new tenancy, unless they obtain an exemption. From April 2020 the MEES was extended to include existing tenancies (as long as the property has an EPC). Landlords are never required to spend more than £3,500 on energy efficiency improvements (cost cap on investment).

Building typology

Privately rented properties. Around 7% of the targeted building stock has an EPC rating worse than label E.

Compliance mechanisms

If a landlord does not provide the requested information or lets a substandard property, they get a monetary fine. The fine ranges between £2000 and £5000 (≈ €2035 and €5585).

Key success factors

- A mature and reliable EPC framework. In the UK and several other countries, there is a lack of confidence in the quality and reliability of EPCs.
- An EPC database which enables the implementing public authorities to check compliance.
- The implementing body must-have resources to uphold and enforce the legislation.
- Avoid too many exemptions to the regulations. In the UK, 'the high-cost exemption criteria are a major reason for not putting in much effort to enforce the MEES to date'.[129]

[127] Domestic Minimum Energy Efficiency Standard Guidance Site (2017). United Kingdom
[128] The Energy Efficiency (Private Rented Property)(England and Wales) Regulations (2015).
[129] RSM. (2019). "Enforcing the Enhancement of Energy Efficiency Regulations in the English Private Rented Sector". RSM Consulting.

Minimum standard for all office buildings

The Netherlands

The parties to the Energy Agreement, including the government, aim for an energy-neutral built environment in 2050, with as an intermediate step at least an average level of the (current) label A for all buildings in 2030. The 2018 amendment of the Dutch Building Decree to require that office buildings have an Energy Efficiency Index of at least 1.3 (equivalent to a 'C' EPC rating) by 1 January 2023 is part of a set of measures to achieve these targets[130].

The Dutch coalition agreement of 2017 also set forward a target of a 49% reduction in CO_2 emissions by 2030 compared to 1990 levels, which for non-residential construction (including office buildings) amounts to 3 MT CO_2 reduction. This target has also been incorporated in the Climate Agreement, which includes the ongoing commitments of the Energy Agreement as well. The label C obligation for offices is therefore also the first step to meet this CO_2 target. A tighter target of an 'A' label by 2030 was considered but not introduced. However, the 'C' requirement by 2023 is expected to be tightened to a higher level in future. In response, commercial financial institutions (ING, ABN) have indicated they will stop financing office buildings that do not meet the standard. This illustrates the effectiveness of MMR as policy instruments.

Legal provision

From 1 January 2023, all office buildings are required to have an Energy Efficiency Index of at least 1.3 (equivalent to a 'C' EPC rating)[131]. As the minimum standard applies to the use of the office building, the duty to comply can be with either the tenant or the building owner.

Building typology

Existing office buildings, with a few exceptions[132], such as office buildings with a total surface area of 100m^2 or less, buildings in which less than 50% of floor area is used for offices, and national, municipal or provincial historic buildings (except protected townscapes and villages). Out of 62,000 offices falling within the scope of this obligation, 56% do not yet have an EPC (no label registered). Of those that do have an EPC, around one-quarter (7,000) has a label of D–G, and about 20,000 have an A-C label. Since the beginning of 2016, the proportion of offices subject to the obligation with a green label (A-C) has increased by an average of 8 percentage points each year.

Compliance mechanisms

Failure to comply will be addressed through administrative enforcement measures, such as periodic penalty payments, a fine and, ultimately, the closure of the office building. The standard is generally enforced by the municipality in which the building is located, but it can also be delegated to another nominated 'competent authority.'

Key success factors

- Enabling framework: (1) online tool providing information on investment costs, energy cost savings and payback time; (2) government-approved energy advisors; (3) grant for the cost of the advice if measures are taken following that advice (in addition to existing financing schemes).

[130] Climate Agreement. (2019). The Netherlands
[131] Bouwbesluit (Building Code) (2012). The Netherlands
[132] Explanatory note Bouwbesluit. (2012). The Netherlands

Tertiary Renovation Decree

France

The ELAN law (Evolution of Housing, Planning and the Digital Environment) was created to improve the building stock in France, including its carbon footprint and energy efficiency level. The 'Décret Tertiaire' (article 175 of the ELAN law) defined and mandates an energy consumption reduction of tertiary buildings.[133]

This is one part of the French government's plan to achieve its long-term objectives, i.e. zero net GHG emissions by 2050.

Status: Planned.

Legal provision

The targeted buildings (i.e. tertiary sector) must reduce their energy consumption (kWh/m²/year) compared to the reference year (which is a year between 2010 and 2020, chosen by the building manager), achieving at least[134] 40% reduction in 2030, 50% reduction in 2040 and 60% reduction in 2050.

The building managers need to provide, via a digital platform, yearly information on the tertiary activity for which the building is used and its area in m². This information must then be published by the building owner and made available to the general public.

This decree applies to both landlords and tenants (the responsibility of each is decided in the rental contract).

Building typology

Non-residential buildings (with a tertiary use area ≥ 1,000 m²)

Exemptions:

- Buildings with temporary construction permits
- Buildings used for religious activity
- Certain public buildings, including buildings of defence, civil security, or national security

Compliance mechanisms

Non-compliance with this decree will be punished by:

- The publication, on a public website, of the non-compliance of the company
- Fine of €1,500 for a physical person
- Fine of €7,500 for legal entities.

Key success factors

- Public communication on (non)compliance.
- Obligation can be transferred to the tenant.
- Platform: needs to be clear and easy to use for building managers.
- Monitoring of the building managers' compliance with the decree (there is a need for a strong incentive and controls so that they all put their real consumption on the platform every year).

[133] Decree 2019-771. (2019) Decree on the reduction of energy consumption of tertiary buildings.
[134] Information website about the Décret Tertiaire. (2019) Citron.

The Energy and Climate Law (Loi 2019-1147)

France

In the French Energy and Climate Law of 2019[135], a ban on the worst-performing buildings (EPC G and F) is included to reduce the emissions of the built environment in France.

Legal provision

Article 22 of the Law prescribes that the primary energy consumption of residential buildings (kWh/m^2/year), defined by an EPC, may not exceed 330 kWh. When a building is rented out or sold after 1 January 2022 it is obliged to include the obligations mentioned in the law in the advertisement.

If the building does not meet the requirements mentioned in article 22 at the point of sale or rent from 2028 onwards, this should also be mentioned in the advertisement. If a building does not meet the requirement in 2028 (primary energy consumption exceeds 330 kWh/m^2/year), an energy audit must be performed which includes suitable renovation measures to meet the targets and the costs.

Building typology

The obligation applies to all residential buildings.

Compliance mechanism

Compliance dates are set in 2022 for advertisements to include the obligation to renovate bad performing buildings described in article 22. From 1 January 2028, the energy performance may not exceed 331 kWh. The energy performance and compliance with the Climate Law should be included in the advertisement. Non-compliance with the inclusion of correct information in these advertisements can result in financial penalties ranging from a maximum of €3000 (private person) to €15,000 for legal entities.

Key success factors

- Phasing out the worst-performing buildings based on energy performance.
- Building owners get sufficient time to prepare the renovation.
- The ‘Troisième ligne de quittance’[136] allows landlords to (partially) share the financial burden of energy-saving measures with tenants.
- The energy performance in the EPC of the building must be included in rental advertisements after 2022.

[135] Law 2019-1147. (2019). Law 2019-1147 related to Energy and Climate. France
[136] Decree 2009-1438. (2009). Decree related to tenant contribution to energy saving work. France

9.2. United States of America

In the USA policymakers recognise the need for more ambitious policies to stimulate energy efficiency in the built environment.[137] MMR is seen as an effective approach to achieve climate targets. The development and implementation of MMR in the USA is just beginning. Different types of MMR in terms of metrics, building segments targeted and compliance are implemented and tested in various jurisdictions of the USA. An overview of different types of compliance is presented in Figure 42.

Recurring metrics for MMR are energy use intensity (EUI), sometimes related to the Energy Star Score, and carbon intensity. The first generation of MMR implemented in the USA suggests that operational rating is more suited for large (commercial) buildings whereas asset rating is more suited for smaller or single-family residential buildings. In certain jurisdictions, only audit obligations and requirements for cost-effective renovation measures exist, rather than whole-building MMR. The building segments most often targeted by MMR in the USA are commercial and multi-family buildings. In contrast to Europe and Canada, single-family houses are often not targeted in the USA, except in Boulder, Colorado.[26] Compliance with MMR is mostly based on compliance cycles and in some cases pegged to trigger points like sale or major renovation.

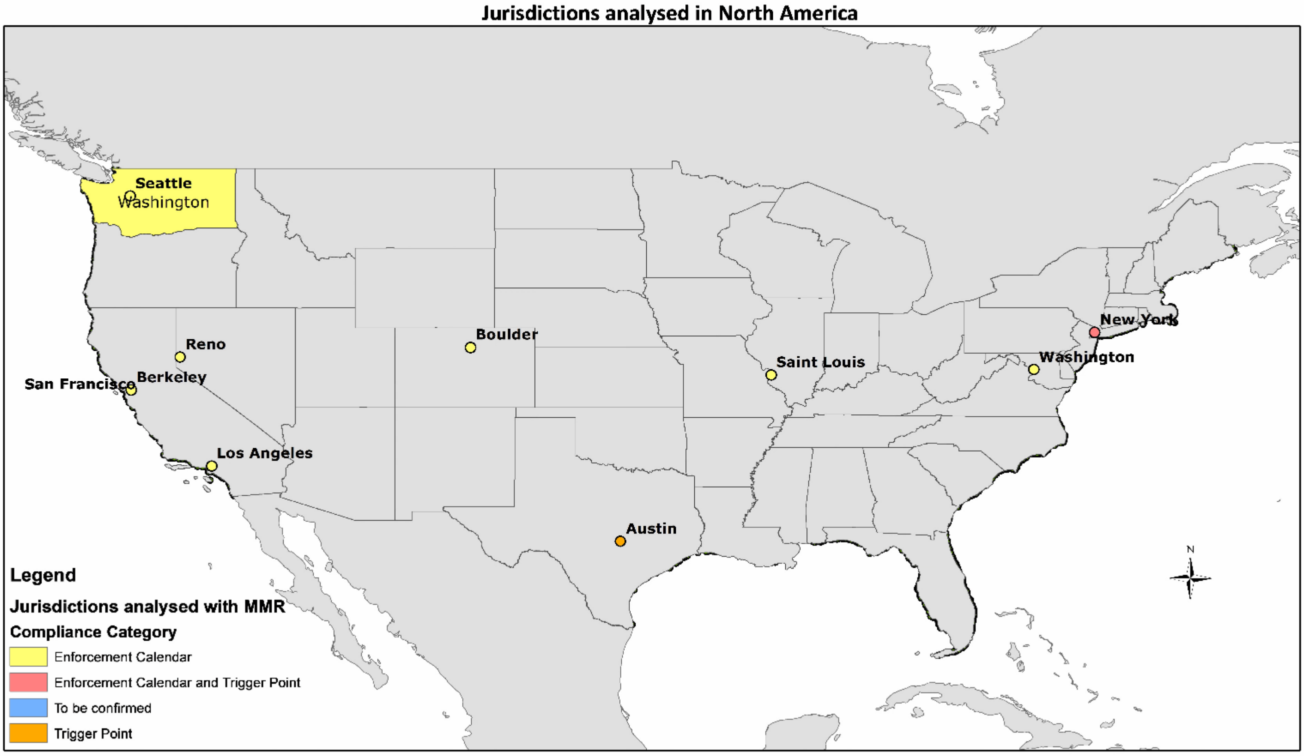


Figure 42. Overview of type of compliance in cases analysed in USA

Some in-depth examples are presented below in table 14.

Name/description of requirement	Location	Building type	Metric	Effective	Compliance category
New York Building Emissions Law (Local Law 97 of 2019)	New York City	Larger buildings (>2300 m^2)	Carbon intensity (tCO_2 eq/m^2)	2024	Enforcement calendar

[137] Nadel, S & Hinge A (2020) Mandatory Building Performance Standards: A Key Policy for Achieving Climate Goals. ACEEE (Available: Online)

					(compliance cycle of 5 years)
Building performance goals	Reno, Nevada	Residential and non-residential buildings (>2700 m²)	Minimum ENERGY STAR score /EUI	2026*	Enforcement calendar (compliance cycle of 7 years)
Building Energy Performance Standards	Washington DC	Larger buildings (> 4600 m²)	Minimum ENERGY STAR score above the median score of district	2026	Enforcement calendar (compliance cycle of 5 years)
Clean Buildings for Washington Act	Washington state	Larger buildings (> 4600 m²)	EUI** (kBtus/m²)	2026	Enforcement calendar (compliance cycle of 5 years)
Boulder SmartRegs program (2010)	City of Boulder	Residential buildings in the rental market	The minimum score on HERS rating system / local carbon and energy checklist	2019	Enforcement calendar (compliance cycle of 4 years)
Building Energy Performance Standard bill	St Louis, Missouri	Residential and non-residential large buildings (>4600 m²)	EUI (kBtus/m²)	2019-2025*	Enforcement calendar (compliance cycle of 4-6 years)
Building Tune-up Ordinance	Municipality of Seattle	Non-residential buildings	Audit obligation + cost-effective renovation	2018-2021*	Enforcement calendar (compliance cycle of 5 years)
Mandatory seismic retrofit program	Los Angeles City	Seismically vulnerable buildings (soft-story buildings)	N/a	2016-2017*	N/a
Building Energy Saving Ordinance	Municipality of Berkeley	Small buildings at trigger point (<2300 m²) Large buildings (>2300 m²) compliance cycle	Audit obligation	2019-2022*	Enforcement calendar (compliance cycle of 5-10 years) + trigger point (sale)
Existing Commercial Buildings Energy Performance Ordinance	Municipality of San Francisco	Non-residential buildings (>900 m²) All buildings (>4600m²)	Audit obligation	2020	Enforcement calendar (Compliance cycle of 5 years) + trigger point (sale)
Existing Buildings Energy and Water Efficiency Program	Municipality of Los Angeles	Larger buildings (>1850 m²)	Audit obligation + cost-effective renovation	2019	Enforcement calendar (compliance cycle of 5 years)
Energy Conservation Audit and Disclosure (ECAD) Ordinance	City of Austin	All buildings	Audit obligation	2008	A trigger point (sale)

ECAD for residential Homes: Information for Home Sellers, Buyers and Real Estate Professionals.	Austin	Multi-family buildings	EUI reduction of 20%	2008	If EUI is more than 150% of the average
New York Sustainable Roof Laws (Local Law 94 of 2019)	New York City	Residential and non-residential large buildings (>2300m^2)	Percentage available roof covered with PV, green roofing or both	2019	A trigger point (major renovation)
Boulder Building Performance Ordinance	City of Boulder	Non-residential buildings	Audit obligation + cost-effective renovation	2020-2027*	Enforcement calendar (compliance cycle of 10 years)

Table 14. Overview of MMR analysed in the USA

*Depending on the building segment/size, starting with public and large buildings

**Energy use intensity

New York Building Emissions Law (Local Law 97 of 2019)

New York City, USA

The law was developed to reduce the adverse impact of climate change and limit GHG emissions. The New York City Council has proposed the Climate Mobilization Act, which aims to reduce the GHG emissions of buildings by 40% in 2030 compared to 2005 levels, and by 80% in 2050.

Legal provision

Local Law No. 97[138] provides a straightforward limit on the amount of GHG a building can emit. It mandates that covered buildings 25,000 square feet (2322m^2) and larger cannot emit GHGs at levels higher than the limits set by the law. It defines mandatory emission intensity limits (metric tons of CO_2/m^2) for different Building Code occupancy groups, based on use and type of the building.

Building typology

It targets large buildings (larger than 2322m^2), both residential and non-residential. The law incrementally expands the share of buildings that are covered by the requirement: 20% of buildings in 2024-2029 and 75% of buildings in 2030-2034.

Compliance mechanisms

Large-building owners must annually report energy and water consumption in compliance with the NYC Benchmarking law (Local Law 84). In the Energy Start Portfolio Management System, where this data is uploaded, the energy use is transposed in kilograms of carbon equivalents ($kgCO_2eq$). The building emission law specifies carbon intensity limits per building segments in these terms. These reports will be checked by the office for energy performance and emissions performance. When buildings exceed the annual buildings emission limit, the owner is liable for a civil penalty equal to the difference between the emission limit for that year and the reported emissions in tonnes of CO_2 multiplied by $268.

A separate office of building energy and emissions performance within the New York City department of buildings has been created to oversee the implementation of the new energy performance-related policies. This office is charged with monitoring buildings energy use and emissions, reviewing building emissions assessment methodologies, building emission limits, goals, and timeframes to further the goal of achieving the emission targets.

Key success factors

- Low-interest loans available through a new Property Assessed Clean Energy programme to finance energy efficiency and green energy through a special assessment on a building's property tax bill.
- Available financial subsidies to support the various measures, including 'green roof tax abatement'.
- The GPRO training programme, a national training and certificate program, trains professionals in sustainable techniques and high-performance construction and maintenance practices.
- City-owned buildings will lead by example and follow stricter rules, with a target of 50% reduction in 2030.

[138] Local Law 97. (2019). New York City Council.

Building Performance Ordinance

Boulder, Colorado, USA

The Building Performance Ordinance (Ordinance No. 8071)[139] is important in the context of the Boulder Building Performance Program.[140] To reduce GHG emissions and increase the energy efficiency of the building stock, the ordinance requires owners of commercial, city and industrial buildings to:

- Annually report the energy usage of their buildings,
- Perform periodic energy assessments
- Perform periodic retro-commissioning and implement cost-effective energy efficiency measures
- Implement one-time lighting upgrades.

Legal provision

The legal provisions part of the Building Performance Program can be divided into two categories: the annual rating and reporting of building energy usage and the implementation of energy efficiency requirements.

The implementation of energy efficiency requirements consists of three parts[141]:

1. Implement one-time lighting upgrade in line with City of Boulder Energy Conversation Code.
2. Perform a quality energy assessment every 10 years, tuning up buildings and calibrating existing functional systems to run as efficiently as possible.
3. Implement cost-effective retro-commissioning measures. The ordinance obliges building owners to implement cost-effective measures within two years after the audit. Cost-effective is defined as each measure with a payback period of two years or less with rebates.

Building typology

- All municipal buildings larger than 460m^2 floor area
- New buildings with a floor surface larger than 930m^2
- All commercial and industrial properties larger than 1850m^2.

Compliance mechanisms

Failure to report on energy data of buildings before the building typology related deadlines results in fines of \$0.027/m^2, up to a maximum of \$1000 per building per day of non-compliance.

Key success factors

- A wide set of support resources, including training programmes for portfolio management, municipal training programmes, assistance for dealing with the split-incentive dilemma and green leases.
- Rebates and other financial instruments to support the implementation, like the level II Energy Assessment Rebates, Excel Energy Retro-commissioning
- Incentives, C-PACE Financing, Boulder County PACE Rebates, solar rebates and grants, clean energy loans and Xcel Energy Prescriptive Rebates.

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[139] Boulder Building Performance Ordinance. (2015). City of Boulder.
[140] Boulder Building Performance Program. (2020) City of Boulder.
[141] Boulder Building Performance Ordinance no. 8071. (2020). Buildingrating.org

9.3. Oceania

In Australia and New Zealand different types of MMR are being implemented (see table 14). Where some focus on public buildings, e.g. the Green Lease Schedules in Australia, the recent adoption of new MMR legislation focuses mostly on the rental sector to improve the health and well-being of tenants, e.g. the Residential Tenancies Regulations (AUS) and the Healthy Homes Guarantee Act (NZ). Metrics relate to minimum insulation values (R-values) and the efficiency and capacity of installations. Compliance is based on specific dates by which building owners must comply, as presented in Figure 43.

An in-depth analysis of two cases is provided below Table 15.

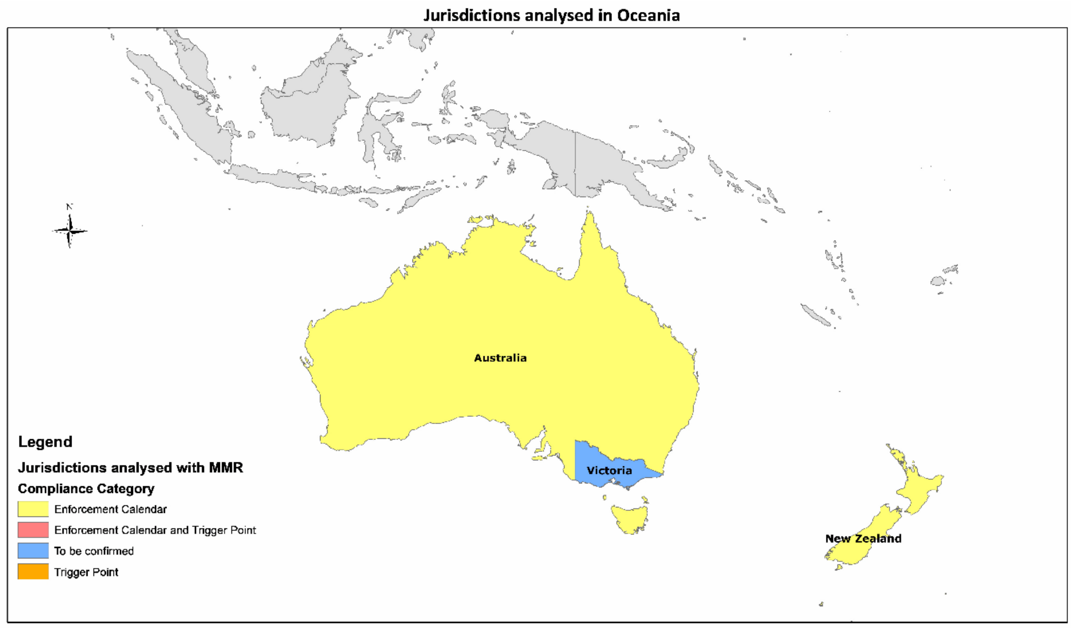

Figure 43. Overview of type of compliance in cases analysed in USA

Name/description of requirement	Location	Building type	Metric	Effective	Compliance category
Green Lease Schedules / National Green Leasing Policy	Australia	Non-residential	NABERS energy rating	2010	Enforcement calendar
Residential Tenancies Regulations 2020	Victoria, Australia	Residential	To be confirmed	2021	TBC*
Healthy Homes Guarantee Act	New Zealand	Residential	Minimum -temperature (°C) -insulation thickness (mm) -ventilation (openable windows/mechanic ventilation) -moisture (effective drainage)	2021	Enforcement calendar

Table 15. Overview of MMR analysed in Oceania

Green Lease Schedules,

Australia

To improve energy efficiency and environmental impacts of government operations, the Australian government enacted the Energy Efficiency in Government Operations (EEGO) policy. The policy aims to overcome traditional barriers to improve the energy efficiency of buildings like the split-incentive dilemma by enabling parties with influence on the building to benefit from implementing improvements. The aim of the policy is to:

1. Reduce energy intensity in operations by 25% in offices
2. Achieve a 20% reduction of energy consumption in office central services by 2021.

Legal provision

The introduced 'Green Leases'[142] contain mutual obligations for tenants and owners of office buildings to achieve efficiency targets. The scheme aims to improve energy efficiency by setting a minimum operational building energy performance standard (i.e the Australian Building Greenhouse Rating – ABGR).[143]

Minimum energy performance requirements for premises above 2000m^2 are a minimum of 4.5 stars within ABGR, which is equivalent to 'excellent' energy performance.

Building typology

All leased government properties and other government buildings.

Compliance mechanisms

Yearly reports on the energy usage of operations made by agencies every financial year, by fuel type and end-use category.

Key success factors

- Public buildings are leading by example.
- Templates for green lease schedules.

[142] Green Lease Schedules. (2010). Forms and templates

[143] Australian Government (2017). Factsheet - Green Lease Schedule

Healthy Homes Guarantee Act,

New Zealand

The aim of the Healthy Homes Guarantee Act[144] is to ensure healthy, dry and warm rental buildings in New Zealand. The Act includes requirements for rental buildings to have a fixed heating device with a specified capacity, minimum underfloor and ceiling insulation, and ventilation requirements.

Legal provision

These objectives of the act are to be achieved through the 'Healthy Home Standards'[145], in which MMR for heating, insulation and ventilation is specified. This 'Residential Tenancies (Healthy Homes Standards) Regulation' became law in July 2019.

The standards prescribe that the heating system must be fixed and able to heat the living space, have a minimum capacity of 1.5 kW, have a thermostat and meet a prescribed minimum heating capacity based on living space building characteristics (Schedule 2)[16]. The insulation must have a minimum R-value (ranging between 2.9 – 3.3 for ceiling insulation and 1.3 for underfloor) depending on the climatic zone. Ventilation requirements relate to the presence of windows and doors that can be opened next to requirements for mechanical ventilation in kitchens (>50L/s) and bathrooms (>25L/s). Additional requirements exist for draught stopping and drainage.

Building typology

Rental buildings in the residential sector

Compliance mechanisms

Compliance dates are formulated for heating, insulation and ventilation and specified for building typologies (e.g. social rent, private rent, etc.). Information about compliance is available on the webpage of the government of New Zealand.[146]

Key success factors

- Addresses the whole rental market.

[144] Healthy Homes Guarantee Act. (2017). Government of New Zealand.

[145] Residential Tenacies (Healthy Homes Standards) Regulations. (2019). Government of New Zealand.

[146] Healthy Homes Standards Webpage. (2020). Ministry of Housing and Urban Development New Zealand.

10. APPENDIX 2: STAKEHOLDER VIEWS

10.1. **Stakeholders *support MMR as a central instrument to decarbonise the building stock***

Around 80% of stakeholders consulted think that MMR is a necessary policy for the EU to decarbonise the building stock by 2050. The same share of respondents also argues that the EU should actively support and encourage MMR.

Stakeholders have been involved in two ways in this study: (1) 113 stakeholders answered an online survey and (2) over 100 stakeholders participated in an online workshop[147]. The stakeholders represent different sectors and professions, including building owner representatives, tenant organisations, installation manufacturers, construction sector, financial sector, public administration, (energy) service providers, civil society, and research institutes. This section highlights some of the most relevant findings and feedback concerning the impact and feasibility of various EU policy tools. The stakeholder views are presented in three sections:

1) What MMR should be supported?

2) How should MMR be designed?

3) What actions should the EU take?

10.1.1. What MMR should be supported?

The main objective of any MMR should be to achieve deep renovation and a link to clear long-term climate and energy targets. Figure 44 displays stakeholders' preferences for different MMR types (one choice possible or multiple?); most respondents think more than one type of MMR could be successful. The large majority of stakeholders consulted via the survey - **three-quarters (74%, or 84 out of 113 survey respondents) - think the MMR should focus on the overall energy performance of the building.** Over half (53%) think MMR could be linked to certain building components, while almost 50% say it should be linked to the building's overall climate performance. Only a quarter (24%) say the MMR should be linked to the occupants' energy behaviour, while less than 3% think the MMR should not encompass energy or climate requirements.

During the stakeholder workshop, support was expressed for carbon efficiency (i.e. maximum GHG/m^2/year) as an MMR parameter because this provides most certainty for the long term and gives the building owner more freedom to decide how the requirement will be met.

Some stakeholders stressed that incorporating indoor environmental quality, embodied carbon and/or accessibility for disabled people in MMR should be considered. In contrast, other stakeholders argued that MMR only focus on energy performance parameters, to be kept simple and effective. The debate around how much to include, or not include, in the MMR resembles the discussion around EPCs.

[147] The survey was divided into three broad parts. The first part assessed the stakeholder views regarding opportunities and risks, as well as success factors and barriers for MMR. The second part explored their preferences for different policy designs. In the third part participants expressed their views about how the EU could best implement, support or introduce MMRs. During the webinar the participants were divided in breakout groups with moderators that discussed these three aspects in more depth. See more details about the survey and workshop in Appendix 2, including additional survey results.

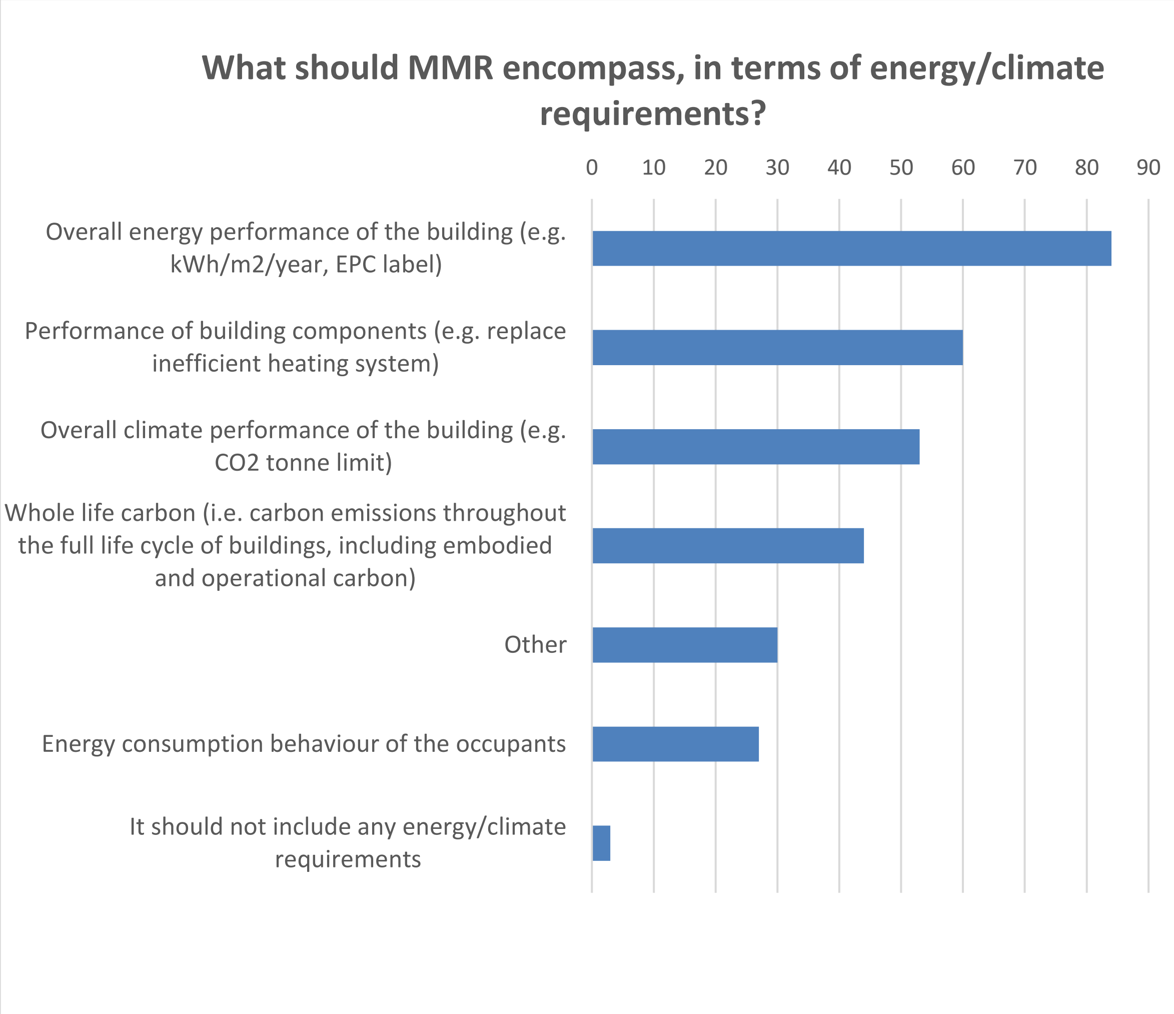

Figure 44: Survey question – stakeholders' preferences for different types of MMR (several votes were possible)

10.1.2. How should the MMR be designed?

The views among stakeholders are diverse when it comes to central design options, such as target groups, trigger points and when the requirement should apply. It was reiterated that these aspects ought to be defined at the national and/or regional level, which explains some of the divergent views.

The stakeholders generally think that MMR can best be applied to the worst-performing buildings, excluding heritage buildings. This will achieve the highest impact in the short term. Additionally, the building owners' ability to comply with the requirement should be considered. The most widespread view (57% of respondents) is that MMR should encompass all building typologies. This view was followed by a focus on larger and more polluting buildings, such as public buildings (41%), multi-family buildings (31%), commercial buildings (30%), all non-residential buildings (28%) and larger buildings and portfolios of building assets (27%). Less popular are low-income households (10%) and social housing (20%). See all answers in Figure 45.

One popular opinion is that MMR could initially best be targeted at public and/or larger commercial buildings. This might, according to the stakeholders, kickstart local renovation markets and improve renovation skills amongst construction workers.

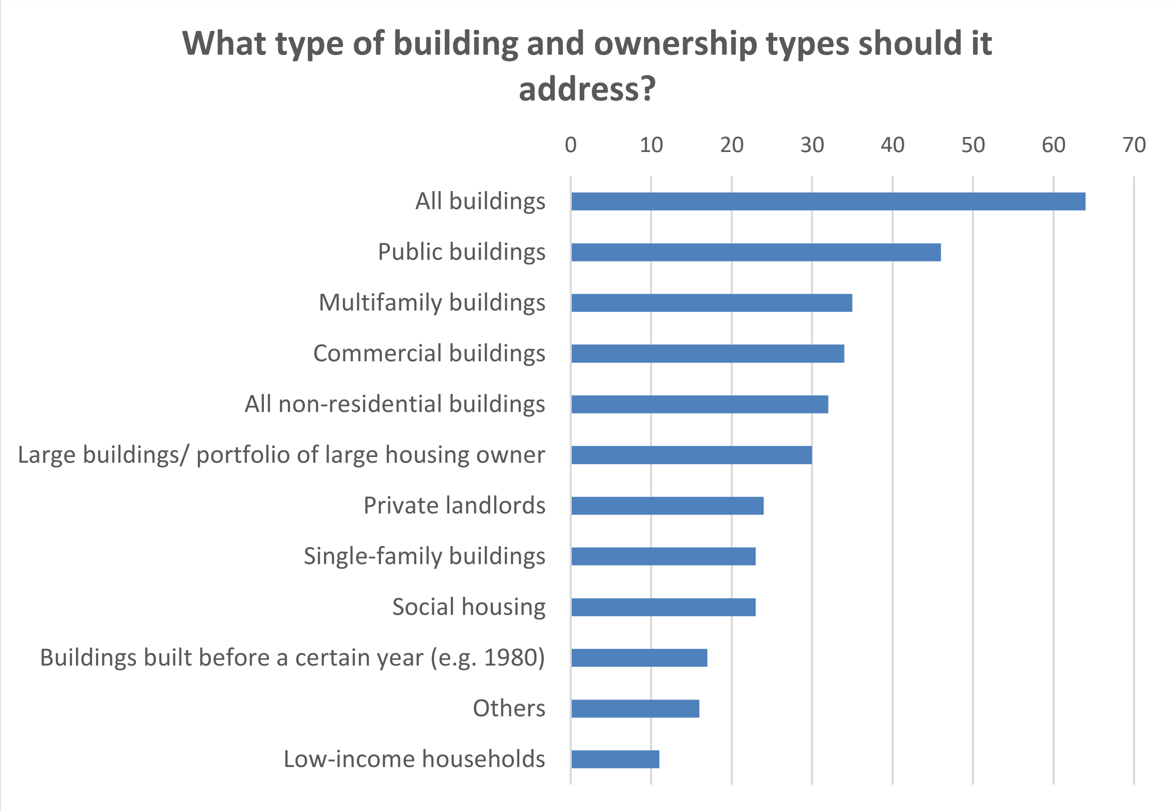

Figure 45: Survey question – building and ownership types to be targeted by MMR (several votes were possible)

Figure 46 shows that many stakeholders want the MMR to include both progressive enforcement of milestones and various trigger points, something reaffirmed in the workshop discussion. In the multiple-choice question on when the MMR should come into effect, most participants say MMR enforcement based on progressive milestones (66%) and trigger points (55%) are the best solutions.

Most stakeholders argue that MMR should support long-term objectives and that the deadlines for the requirements should be planned and communicated well in advance. This gives landlords and the market time to adapt and take actions. The enabling framework could also be coupled to long-term targets and stimulate quick action. Financial measures could be designed to reward early action with high support and be reduced closer to the deadline.

The argument for linking MMR to a building renovation passport (which is supported by 42% of the respondents) is to avoid technical and economic lock-in effects. Building renovation passports could support building owners to take adequate renovation measures, which makes sense in the short term as well as in the long term. A couple of stakeholders argue that MMR supported by the EU should only allow one-stage deep renovations. Other participants perceived the choice between staged and one-step deep renovation as too simplistic and called for an open mindset to find a balanced solution.

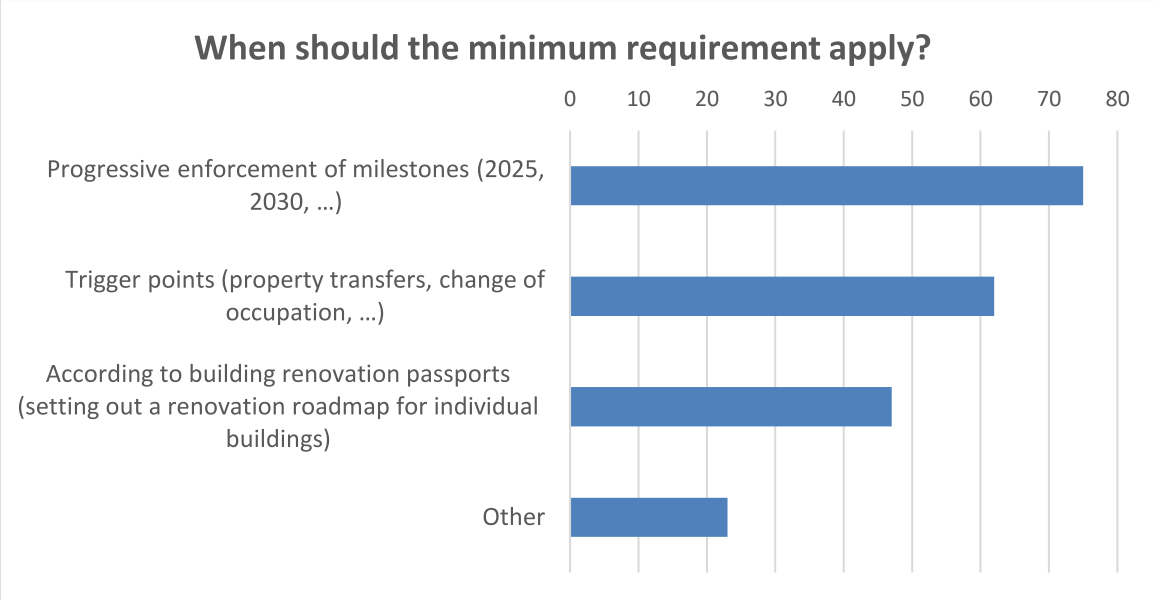

Figure 46: Survey question – When should the requirement apply? (several votes were possible)

Stakeholders view the EPC framework as a natural way of implementing and enforcing MMR by the EU. It was, however, also stressed that the reliability of EPCs and their (lack of) comparability across the EU remains a barrier. Concerning EPCs, it was also concluded that they could be expanded to include other non-energy parameters like indoor environmental quality, which could then be taken into account by future MMR.

Error! Reference source not found.7 displays what the stakeholders view as the most s uitable trigger points for MMR. Some 86% (97 out of 113 respondents) say that major renovation or building-related construction work is the most suitable trigger point, which partially links to what Article 7 of the EPBD declares[148]. Most respondents think 'property transfer' (62%) and 'change of use' (50%) are good trigger points for MMR.

[148] Article 7 of the EPBD states that "Member States shall take the necessary measures to ensure that when buildings undergo major renovation, the energy performance of the building or the renovated part thereof is upgraded in order to meet minimum energy performance requirements set in accordance with Article 4 in so far as this is technically, functionally and economically feasible."

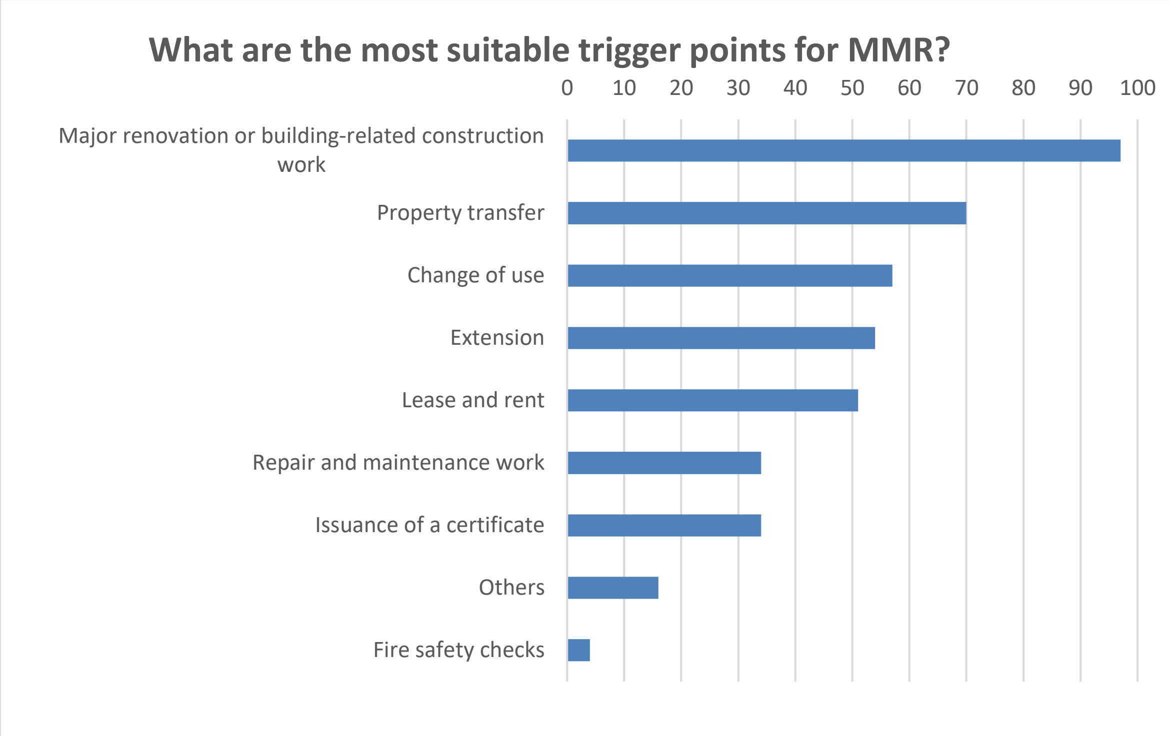

Figure 47: Survey question – Most adequate trigger points (several votes were possible)

10.1.3. What should the EU do?

There is almost a consensus among stakeholders on the view that MMR cannot function without a supportive policy framework. Participants mentioned financial support schemes (green loans and grants), awareness and communication campaigns, long-term planning tools, training of experts as well as a compliance and enforcement strategy, as essential enabling measures. The survey shows (see Figure 48) that most stakeholders view all enabling measures to be, at least, moderately important. Financial support is seen as the most important measure (85% say it is 'very important' or 'important'), followed by information measures (73%) and long-term planning tools (80%).

It was also stressed that the EU must take further actions to improve the trustworthiness of EPCs and make sure data supporting MMR is reliable and comparable. Stakeholders suggested that the EU can play an important role in harmonising data collection and facilitating the comparison of EPCs within the EU. Concerning the supply of construction materials and building installations, MMR could play a role in ensuring that, even if MMR is defined on a local scale, it is still part of a wider and comparable European framework.

In addition, continuing the work on raising awareness on building performance, for example through one-stop shops, was frequently referred to as part of the solution.

Some stakeholders warn of the additional financial burden MMR can impose for some building owners and tenants. This is in general seen as the most important aspect that should be addressed and solved. Financial support is seen as the most suitable solution to this barrier.

On the role of the EU, the general view was that Member States must have the flexibility to define the ambition level, enforcement mechanisms and certain design features. A few stakeholders highlighted that the EU should provide guidance in the form of overviews of possible measures and allow local and national authorities to determine what is most suitable.

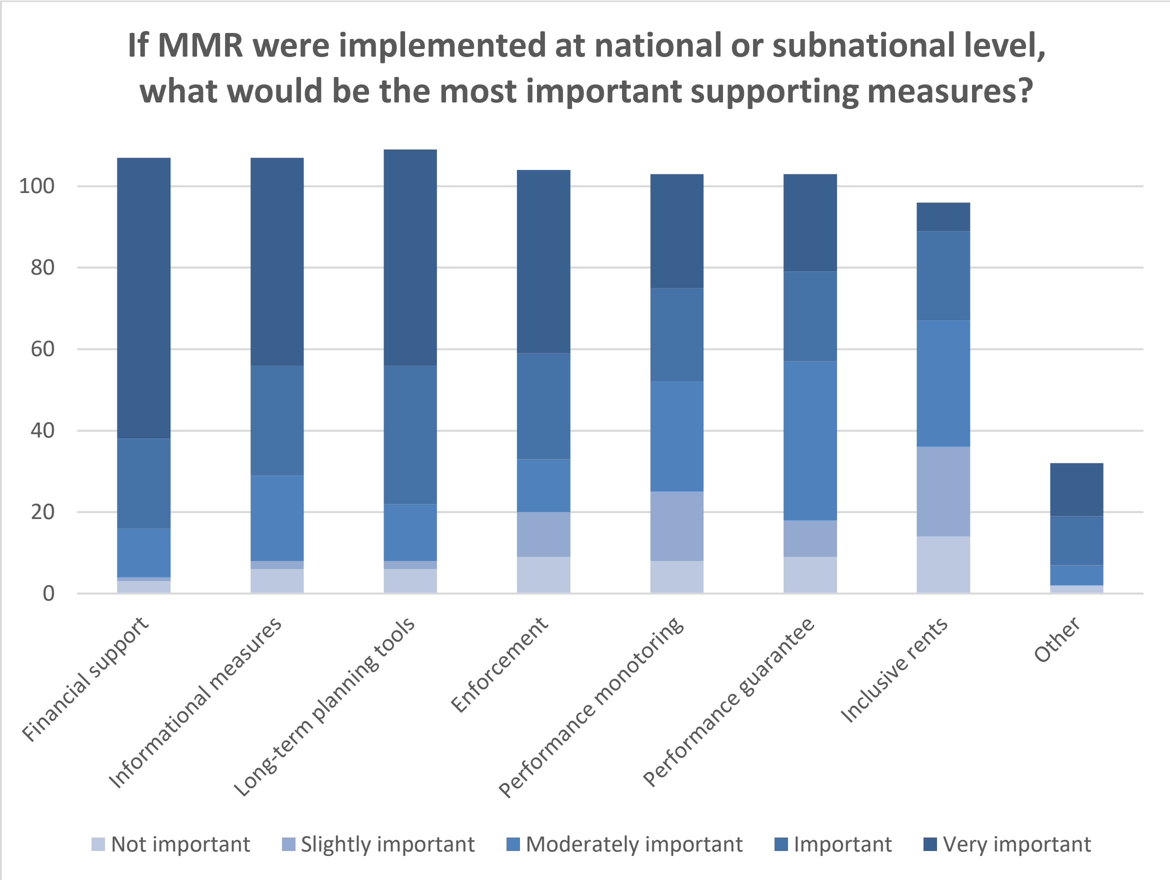

Figure 48: Importance of measures in the enabling framework

Several stakeholders consider embodied carbon to be relevant in the context of MMR. In particular, the technical installations and materials in energy-efficient buildings can have a considerable impact over the lifetime of a building. If MMR is not suitable to address the issue, this issue should be addressed through another support framework.

11. APPENDIX 3: IMPACT AND FEASIBILITY OF THE MMR MODELS

11.1. MMR model 1: Progressive enforcement of MMR for existing buildings

Impact consideration

Indicator	Strengths	Weaknesses
Techno-economic aspects		
Renovation rate	By triggering the renovation of the worst-performing buildings (i.e. over 50% of buildings with an EPC have a rating worse than D[149]) by 2030, the model has the potential to bring the renovation rate to 3-5%/year in the period to 2030 (i.e. triggering the renovation of 30% to 50% of buildings within 10 years). The impact on the renovation rate will depend on how the MMR is designed, regulated and enforced.	No weakness.
Renovation depth	Visibility of the long-term targets contributes to steering all renovation measures towards the long-term objective.	Progressive enforcement might trigger step-by-step renovations before one-stage deep renovations. If the progressive enforcement calendar is defined right away (i.e. what performance is required by 2050, including milestones) it would reduce this risk, as building owners and investors would also renovate to make their building asset "future proof" (i.e. not just complying with the pending requirement but the ones that will come into force in 10-20 years time). Without a BRP, there is a risk of technical and economic lock-in effects, if shallow renovations and incentivised, without considering the long-term objective.
Renovation quality	The EPC can be used to prove post-measure compliance (as done with financial subsidies in several of the Member States), which fosters higher quality of works.	Operational (actual) energy use often differs from the theoretical energy use (asset rating). The current EPC frameworks are predominantly focused on theoretical energy use, which might lead to that the full scope of estimated energy savings might not materialise in actual energy savings.

[149] Calculation based on data from BPIE (2018); 97% of buildings in the EU need to be upgraded. (Available: Online)

Cost-optimality	The EPBD says EPC ought to indicate as to where the user can receive more detailed information, including information on the cost-effectiveness of the recommendations made in the EPC.	To reach equal final performances, one-stage deep renovations are, in general, cheaper than staged deep renovations. If the MMR model triggers staged renovations, the overall cost will increase. The most cost-optimal decarbonisation pathway might not be reached if renewable energy consumption and whole-life carbon considerations are excluded in the calculations.[150] These aspects can be tackled in parallel to the MMR. While this model focuses on individual buildings, building managers might have a more cost-optimal pathway to the final target (e.g. deep renovation of 20% of their buildings every five years).
Socio-economic aspects		
Split incentives	The progressive MMR reduces the barrier of the split-incentive dilemma since the decision to invest in energy renovations is mandatory.	The actor bearing the cost to comply with the MMR might not be the same as the one getting the benefits. At worst, this could lead to a higher demolition rate or vacant apartments.
Energy Poverty	Improving the worst-performing buildings, in which a larger share of energy-poor persons live, would reduce energy bills and improve health and wellbeing.	Without clear regulation, there is a risk the cost of the renovation measures will fully be put on the tenants (through rent increases), which then could have an adverse effect.
EU long-term targets		
2030 GHG milestone	The model alleviates the worst-performing buildings first, contributing to the 2030 targets if being implemented and enforced before this date.	The focus on the worst-performing buildings does not foster improvements in the rest of the building stock. Energy savings will be more difficult (more expensive) to achieve after the initial round of renovations.
Carbon neutrality by 2050	The model ensures that targeted segments do their share in energy efficiency improvements. If the progressive calendar is defined to be aligned with the 2050 target, it could ensure the building stock is decarbonised by 2050.	Additional actions are needed to decarbonise the remaining heat demand. Whole-life carbon impacts are not considered and need to be tackled in parallel.
Renewables	Local renewable production can be integrated into certain types of EPC (e.g. in France and Wallonia with solar PV).	The focus on energy efficiency does not explicitly foster the development of renewable production.

Table 16. Table impact assessment MMR Model 1

[150] Cost-optimal decarbonisation pathways include a mix of approaches, all of which mandate a high level of energy efficiency/energy performance of the building and the remaining energy demand being covered by renewable heat (see e.g. ifeu, Fraunhofer IEE and Consentec (2018). Building sector Efficiency: A crucial Component of the Energy Transition. A study commissioned by Agora Energiewende). (Available: Online)

Illustrative impact consideration

MMR model 1 is modelled below (Figure 49 and 50) as a progressive ban on the worst-performing buildings, meaning that all EPC F buildings should be renovated by 2035, then all EPC E buildings by 2040, etc. It is assumed that by 2050 all buildings have an EPC rating of B or better. It is also assumed that a "decarbonised building stock" implies a long-term primary energy consumption target of 100kWh/m²/year for existing buildings. The 'theoretical' primary energy consumption is corrected to account for the lower actual energy consumption in highly efficient buildings. This leads to a reduction of the final energy consumption by 2050, with reference to 2020, of 39% for France and 57% for Germany (which are used to illustrate the potential impact). The expected adverse impact of the performance gap is illustrated and shows that these results could be reduced by 16 percentage points if this issue is not solved. The performance gap could be tackled in parallel to the MMR model and be reduced, through systemic research and quality assurance measures.

While MMR model 1 translates into reductions of the final energy consumption, the related impact of GHG emissions is more uncertain. Reaching the minimum performance level will be achieved by a combination of energy efficiency of the building envelope and retrofits to more efficient heating systems with lower carbon intensities (e.g. from liquid-fuel boilers to condensing gas boilers and from gas and liquid boilers to heat pumps and biomass-based technologies). For the sake of the illustration, it is considered that all liquid-fuelled boilers will be replaced by heat pumps. This reduces the GHG intensity of heating by 29% for France and 37% for Germany. Combined with the reduction of the final energy consumption, this reduces GHG emissions by 56% and 73% respectively.

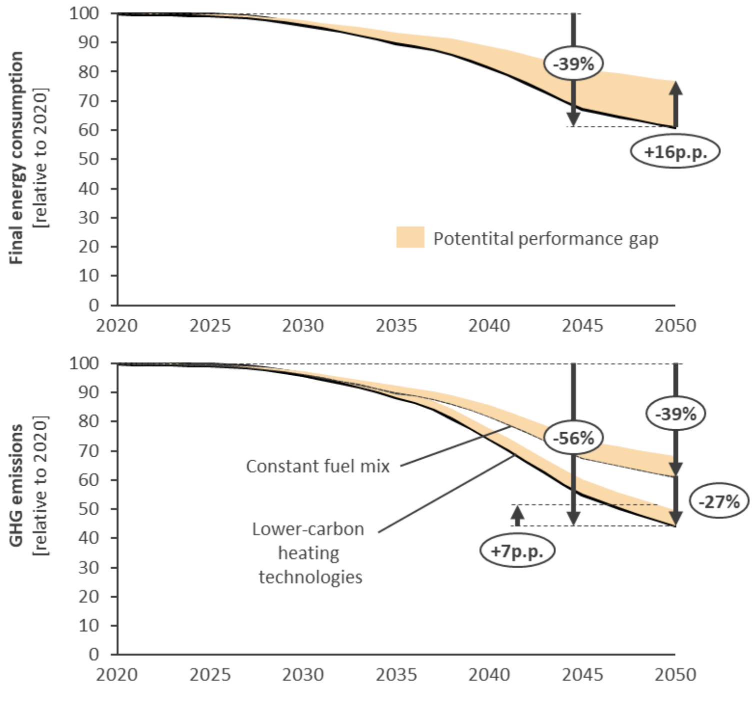

Figure 49 – Illustrative impact assessment of MMR model 1 on the French residential buildings stock

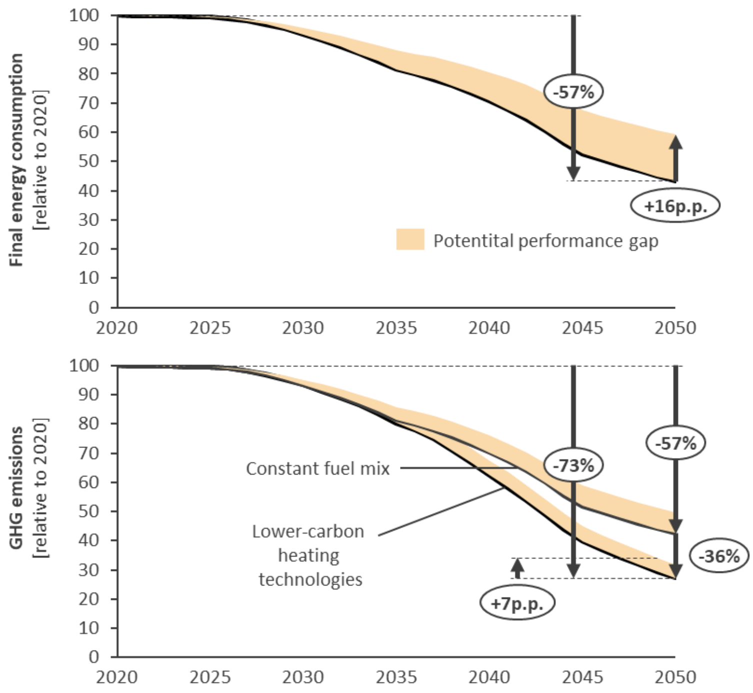

Figure 50 – Illustrative impact assessment of MMR model 1 on the German residential buildings stock

Feasibility assessment

Indicator	Strength	Weaknesses
Maturity of existing "infrastructure"	The EPC infrastructure already exists in all Member States, with energy experts and databases in place.	Most Member States have less than 10% of their building stock covered by EPCs. The EPCs diverge in quality and reliability and control mechanisms. The EPC frameworks must improve in all jurisdictions, in terms of availability and reliability.
	Several Member States have robust EPC databases that can be used to check compliance.	Public databases are not in place in all countries, so the quality of the gathered data differs between the Member States.
Simplicity	Excluding renewables makes the calculations simpler and easier for building owners to understand. Many building owners are familiar with the EPC.	
Ease of compliance	The existing EPC infrastructure can easily be adapted to check for compliance.	

Table 17. Feasibility assessment MMR Model 1

11.2. MMR model 2: Progressive enforcement of minimum carbon performance requirements for all existing buildings

Impact assessment

Indicator	Strengths	Weaknesses
	Socio-economic	
Renovation rate	By triggering the renovation of the worst-performing buildings (i.e. over 50% of buildings with an EPC have a rating worse than D[151]) by 2030, the model has the potential to bring the renovation rate to 3-5%/year in the period to 2030 (i.e. triggering the renovation of 30% to 50% of buildings within 10 years). The impact on the renovation rate will depend on how the MMR is designed, regulated and enforced.	
Renovation depth	Visibility of the long-term targets contributes to steering all renovation measures towards the long-term objective.	Opening the integrate (on-site) renewables in the minimum standard brings new risks of lock-ins as production units could be oversized for buildings where the energy efficiency potential has not been captured yet. For renovation occurring up to 2030, this might,, however, be alleviated by the shorter lifetime of heating systems compared to building envelopes.
		Progressive enforcement might trigger step-by-step renovations before one-stage deep renovations. If the progressive enforcement calendar is defined right away (i.e. what performance is required by 2050, including milestones) it would reduce this risk, as building owners and investors would also renovate to make their building asset “future proof” (i.e. not just complying with the pending requirement but the ones that will come into force in 10-20 years). Without a BRP, there is a risk of technical and economic lock-in effects, if shallow renovations and incentivised, without considering the long-term objective.
Renovation quality	The EPC can be used to prove post-measure compliance (as done with financial subsidies in several Member	Operational (actual) energy use often differs from the theoretical energy use (asset rating). The current EPC frameworks are predominantly focused

[151] Calculation based on data from BPIE (2018); 97% of buildings in the EU need to be upgraded. (Available: Online)

	States), which fosters higher quality of works.	on theoretical energy use, which might lead to that the full scope of estimated energy savings might not materialise in actual energy savings.
Cost-optimality	Expressed in terms of GHG emissions, the requirements facilitate the cost-optimal combination of investment in building performance or renewable energy sources.	To reach equal final performances, one-stage deep renovations are, in general, cheaper than staged deep renovations. If the MMR model triggers staged renovations, the overall cost will increase.
		Optimising the combination of energy efficiency and renewables on an individual building level, risk leading to the non-consideration of macro-economic costs (e.g. additional investments in the power infrastructure), which are not reflected in the microeconomic model for the individual building.
Socio-economic		
Split incentives	The progressive MMR reduces the barrier of the split-incentive dilemma since the decision to invest in energy renovations is mandatory.	The actor bearing the cost to comply with the MMR might not be the same as the one getting the benefits. At worst, this could lead to a higher demolition rate or vacant apartments.
Energy Poverty	Improving the worst-performing buildings, in which a larger share of energy-poor persons live, would reduce energy bills and improve health and wellbeing.	In contrast to MMR model 1, more investment will go to renewable energy in model 2, which have no real impact on energy poverty. Therefore, ensuring a minimum energy performance level should be ensured, while the final stages to a decarbonised building can be investments in renewable energy if these investments are considered more cost-optimal for the individual building.
EU long-term targets		
2030 GHG milestone	The model alleviates the worst-performing buildings first, contributing to the 2030 targets if being implemented and enforced before this date.	The focus on the worst-performing buildings does not foster improvements in the rest of the building stock. Energy savings will be more difficult (more expensive) to achieve after the initial round of renovations.
2050 carbon neutrality	The model focusses on mitigation of carbon emissions and is thus more aligned with EU's 2050 climate targets. Which are expressed in CO_2.	The MMR model states that whole-life carbon considerations can be included when standards and infrastructure for doing this are mature enough. If not included, all related emissions would not be included nor considered.
Renewables	The model fosters investments in renewables, which contributes to the renewable targets.	

Table 18. Impact assessment MMR Model 2

Illustrative impact consideration

MMR model 2 formalises targets on GHG emission intensities (i.e. $kgCO_2/m^2/year$). It is considered that the EU carbon neutrality 2050 target is transposed as a long-term target for the performance of all residential buildings (an average target for the buildings stock would lead to similar results). Therefore, the estimated GHG emissions are reduced down to zero, which is reflected in the impact consideration figure.

The evolution of the final energy consumption is expected to differ from MMR model 1. MMR model 2 might result in a higher share of renewable energy investments, instead of energy efficiency investments, which could lead to lower reductions of the final energy consumption. This is not captured in this simplified model. Instead, it is considered that renewable heat investments are added to investments in energy efficiency, i.e. on top of the energy savings obtained with MMR model 1, so the deployment of low-carbon and higher-efficiency heating technologies slightly increases the final energy consumption reductions. The possible impact of a performance gap is illustrated with the light orange range, as in MMR model 1.

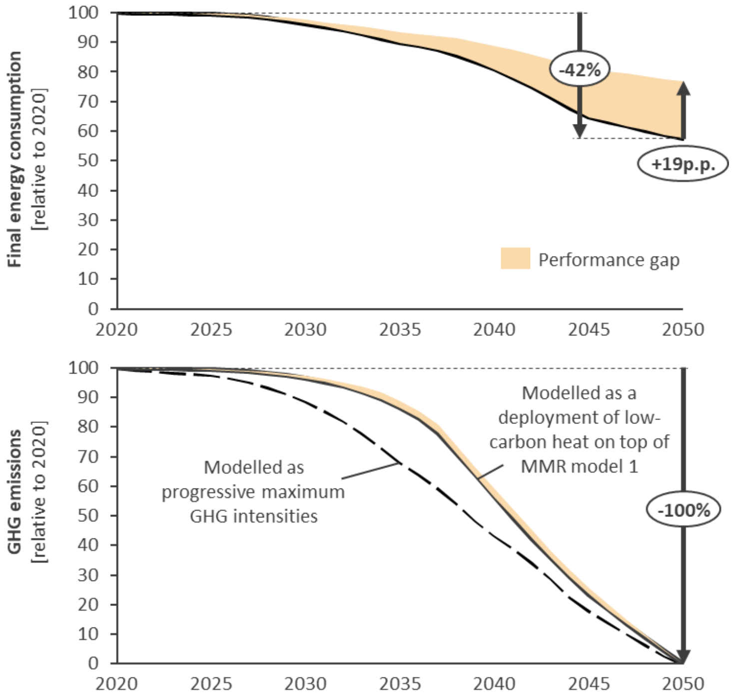

Figure 51 – Illustrative impact assessment of MMR model 2 on the French residential buildings stock

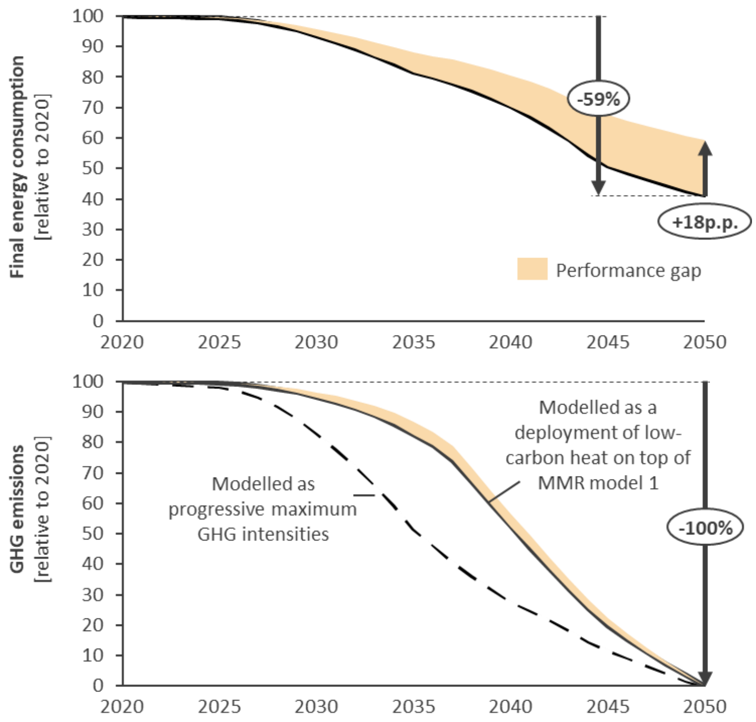

Figure 52 – Illustrative impact assessment of MMR model 2 on the German residential buildings stock

Feasibility assessment

Indicator	Strength	Weaknesses
Maturity of existing "infrastructure"	Emission factors for all energy vectors are available and used by the Member States for their national inventories of GHG emissions. The EPC infrastructure already exists, to different extents, in all Member States. The EPBD allows the Member States to include an indication of carbon emissions in their EPC, which is done by several Member States (e.g. France, Portugal and Poland). The reliability of EPCs is improving (though far from being perfect) offering a head start over any new instrument.	If whole-life carbon is included, there is a data gap to properly evaluate embodied emissions of construction materials and products. No common database of these emissions exist.
	Several Member States have robust EPC databases that can be used to check compliance.	Public databases, of current EPC, are not in place in all countries so the quality of the gathered data differs between the Member States.
Simplicity	GHG emissions of the building are already the main indicator for nearly zero-energy buildings in some countries (NO, ES) or provided as an extra indicator (AT, EI, LU, RO). Translating the primary energy consumption (kWh/m^2), as given in the EPC, to GHG/carbon emissions CO_2 is not a complicated process.	CO_2 emissions depend on energy supply contracts.

		The calculation and message to the building owner become more complex, which can hamper effective communication.
Ease of compliance	The existing EPC infrastructure can easily be adapted to check for compliance.	

Table 19. Feasibility assessment MMR Model 2

11.3. MMR model 3: Progressive real carbon emissions budget

No impact consideration modelling was conducted for model 3, as most of the assumptions are mirroring model 2.

Impact consideration

Indicator	Strengths	Weaknesses
	Techno-economic	
Renovation rate	By triggering the renovation of the worst-performing buildings (i.e. over 50% of buildings with an EPC have a rating worse than D[152]) by 2030, the model has the potential to bring the renovation rate to 3-5%/year in the period to 2030 (i.e. triggering the renovation of 30% to 50% of buildings within 10 years). The impact on the renovation rate will depend on how the MMR is designed, regulated and enforced.	Depending on how it's being enforced, some building owner would opt for changing behaviour (which could have adverse health effects).
Renovation depth	Visibility of the long-term targets contributes to steering all renovation measures towards the long-term objective. Avoids risk of the performance gap, as the requirement is set on actual carbon use. The progressive reduction of GHG emissions can be aligned with EU's long-term objective for the building stock (i.e. the standards can require zero emissions by 2050).	Progressive enforcement might trigger step-by-step renovations before one-stage deep renovations. If the progressive enforcement calendar is defined right away (i.e. what performance is required by 2050, including milestones) it would reduce this risk, as building owners and investors would also renovate to make their building asset "future proof" (i.e. not just complying with the pending requirement but the ones that will come into force in 10-20 years).
Renovation quality	Ensures actual carbon emission savings, due to a real decrease in carbon emissions. The performance gap is not an issue in this model.	
Cost-optimality	Expressed in terms of GHG emissions, the requirements leave room to either invest in building performance or renewable energy sources.	To reach equal final performances, one-stage deep renovations are, in general, cheaper than staged deep renovations. If the MMR model triggers staged renovations, the overall cost will increase.
	Expressed in terms of GHG emissions, the requirements facilitate the cost-optimal combination of investment in building performance or renewable energy sources.	Optimising the combination of energy efficiency and renewables on an individual building level, risk leading to the non-consideration of macro-economic costs (e.g. additional investments in the power infrastructure), which are not

[152] Calculation based on data from BPIE (2018); 97% of buildings in the EU need to be upgraded. (Available: Online)

		reflected in the microeconomic model for the individual building.
Socio-economic		
Split incentive	The enforcement calendar alleviates the split-incentive dilemma by mandating when to invest in energy renovations.	The actor bearing the cost to comply with MMR might not be the one getting the benefits. A risk that building owner forces tenants to reduce heating, in order to comply with the standard.
Energy poverty		Risk of changing behaviour instead of investments in better buildings. The model is less suitable for residential buildings.
EU long-term targets		
2030 GHG milestone	The model alleviates the worst-performing buildings first, contributing to the 2030 targets if being implemented and enforced before this date.	The focus on the worst-performing buildings does not foster improvements in the rest of the building stock. Energy savings will be more difficult (more expensive) to achieve after the initial round of renovations.
	The model raises awareness and enhances a change of habits towards decreased emissions, beyond insulation and towards the whole emission spectrum, including change of comfort temperature, numbers of rooms heated, use of appliances, etc.	People might consider it as leading to a decreased quality of life. Financial, administrative and counselling support to poor and medium revenue households is of prime importance for the acceptance of the model.
2050 carbon neutrality	The actual carbon use is a more accurate indicator and fully aligned with the long-term target, which is expressed in CO_2.	The MMR model states that whole-life carbon considerations can be included when standards and infrastructure for doing this are mature enough. If not included, all related emissions would not be included nor considered.
Renewables	The model fosters investments in renewables, which contributes to renewable energy targets. The model encourages self-consumption for 'prosumers' since self-consumption will not be taken into account.	

Table 20. Impact assessment MMR Model 3

Feasibility assessment

Indicator	Strengths	Weaknesses
Maturity of existing “infrastructure”	Buildings across all sectors do measure and declare their consumption, hence data already exists. Smart meter data, which is prefered to monthly utility bills, exist in most Member States. Although, the roll-out is still underway.	Data privacy and security ought to be considered. In some countries, actual energy consumption data is considered sensitive.
Simplicity		The communication to the building owner/person responsible for the activity becomes more complicated, which can hamper effective signalling.
		A just and fair definition of the carbon budget must be defined across all sectors, all activities and all households, which is a challenging task.
Ease of compliance	Expressed in actual carbon use, the requirement leaves room to either invest in energy performance or renewables, changing behaviour (awareness-raising) or renewables.	Full decarbonisation might only be achievable if heat supply is decarbonised. This is not the responsibility of the building owner/occupant but depends on the transformation of the supply sector.

Table 21. Feasibility assessment MMR Model 3

11.4. MMR model 4: Mandatory improvements trigger by indoor environmental quality deficiencies

Impact analysis

Indicator	Strengths	Weaknesses
	Techno-economic	
Renovation rate	Can trigger a substantial number of energy renovations, in particular of the worst-performing buildings with regards to energy efficiency and buildings with better energy performance but that do not meet targeted IEQ levels.	Not primarily focused on energy renovations.
Renovation depth	Can enable a more holistic view of deep renovation, considering energy performance as well as IEQ aspects. Future technologies, such as sensors and smart meters, can enable a more accurate evaluation of the buildings.	Progressive enforcement triggers step-by-step renovations and does not necessarily foster one-stage deep renovations. Risk of fragmented measures dealing with one deficiency (e.g. ventilation rate).
Renovation quality	Inadequately designed deep energy renovation can lead to reduced IEQ. Explicit IEQ requirements help to raise awareness and ensure that IEQ performance is part of the design of renovation projects. The energy or carbon efficiency improvements will remain subject to minimum requirements regarding IEQ, which can foster quality renovations.	
Cost-optimality	IEQ investments will improve what is described as “multiple benefits”, including better health, productivity and wellbeing. Research indicates the societal benefits could be considerable.	IEQ is not considered in the current cost-optimal calculation. Most non-energy investments would, therefore, not be considered “cost-optimal”
	Socio-economic	
Split incentives	The enforcement calendar alleviates the split-incentive dilemma when it decides to invest in the overall quality of the building.	The actor investing to comply with the MMR might not be the one benefiting. Many of the benefits are societal and might not be considered tangible for the person making the financial investment.
Energy poverty	Inadequate IEQ is a frequent problem for the energy-poor community, where it has adverse effect on health and wellbeing.	
	EU long-term targets	
2030 GHG milestone		The model, would alone, have a limited impact on the 2030 GHG milestone.

Carbon neutrality by 2050		The model, would alone, have a limited impact on the 2050 carbon neutrality goal.
Renewables		The focus on IEQ does not explicitly foster the development of renewable energy.

Table 22. Impact assessment MMR Model 4

Illustrative impact assessment:

MMR model 4 assumes that all unhealthy buildings will be renovated by 2030, in addition to what is already triggered by MMR model 2. Given that reasons to renovate go beyond energy efficiency, it is considered that deep renovations can be triggered (both two-stage and one-stage renovations are considered). The impacts of this MMR model derive from deeper and earlier renovations.

Besides buildings where people are unable to keep warm, unhealthy buildings include buildings with e.g. leaks, damp and rot that might not be the worst-performing ones in terms of energy efficiency. Based on the question 'Do you have any of the following problems with your dwelling/accommodation?', 16%[153] of households answered yes, qualifying their dwelling as unhealthy – yet only 9%[154] (of these[155]) were unable to keep their home warm. In this impact assessment, we consider that unhealthy buildings with problems beyond minimum energy efficiency requirements will undergo deeper renovations, ranging from two-stage to one-stage renovations toward the long-term targets. We further assume that dwellings where households are unable to keep warm stand within the worst energy-performing EPC class (i.e. class F), and that the ones with health issues other than energy efficiency are equally distributed between classes E and D. The modelling of MMR model 4 assumes that the renovation of all of these buildings is triggered by 2030.

The orange range shows the results for renovation depths varying from two-stage to one-stage renovations toward the long-term target (EPC B with 100kWh/m²/year). As discussed above, the broader scope also fosters holistic quality considerations in energy renovations, avoiding new unhealthy situations resulting from wrong design or implementation.

[153] 12% for France and 11% for Germany. See EU's Energy Poverty Observatory.
[154] 6% for France and 4% for Germany. See EU's Energy Poverty Observatory.
[155] This is an interpretation.

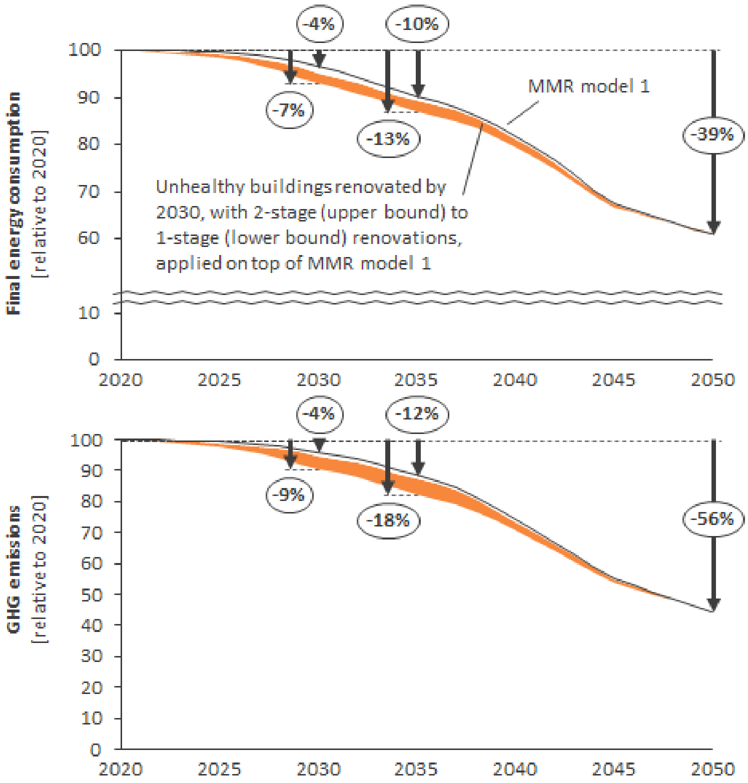

Figure 53 – Illustrative impact assessment of MMR model 4 on the French residential buildings stock

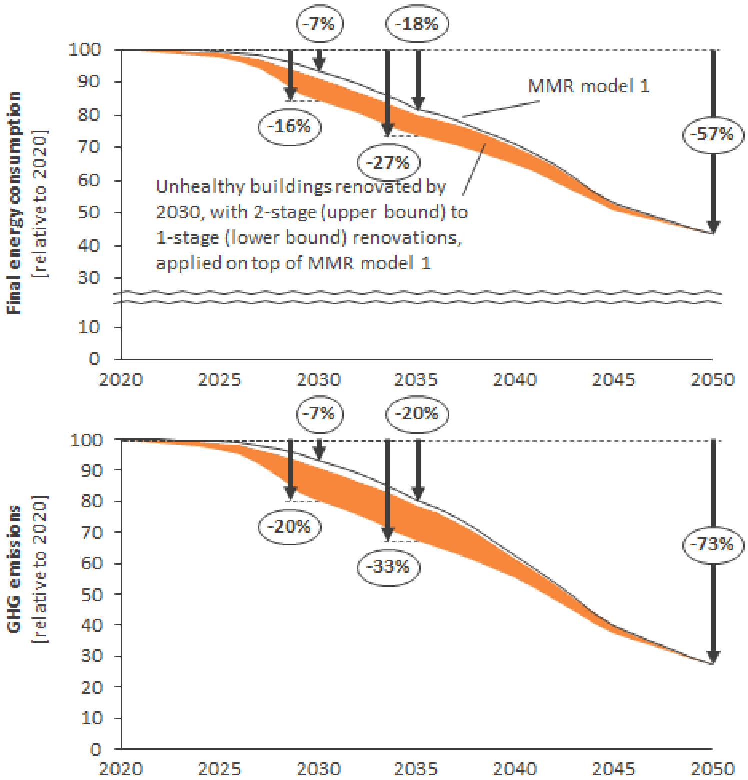

Figure 54 – Illustrative impact assessment of MMR model 4 on the German residential buildings stock

Feasibility analysis

Indicator	Strength	Weaknesses
Maturity of existing “infrastructure”	The policy option requires a larger focus on non-energy aspects, increasing people’s awareness and expertise in that field.	EPCs could be adapted to become effective instruments to track not only a building’s energy performance but also its overall IEQ by providing evidence-based information.
Simplicity		IEQ is not commonly addressed and various approaches exist to assess it. Having a common and uniform methodology is challenging.
Ease of compliance		Regular IEQ checks are not carried out and no simplified procedure (to check ventilation, noise, thermal comfort, lighting etc.) is in place.

Table 23. Feasibility assessment MMR Model 4

11.5. MMR model 5: Progressive implementation of pre-defined renovation steps based on a building renovation passport

Impact consideration

Indicator	Strengths	Weaknesses
	Techno-economic	
Renovation rate	The model alleviates the worst-performing buildings first, contributing to the 2030 targets if being implemented and enforced before this date.	If we assume that the budget for renovation measures is fixed, a fraction of this will be diverted to renovation advice (BRP) instead of actual energy/carbon saving measures. It is, however, likely that the improvement of type of measures (saved kWh per invested EUR) would be higher and exceed the initial cost.
Renovation depth	The BRP allows every owner to have a clear overview of the cost-optimal way to reach the 2050 target. The BRP would ensure the cost-optimal path to a deep renovation is ensured, in one or several steps. The existing EPC recommendations are too often generic and don't take into account the building's trajectory towards the long-term target.	
Renovation quality	The EPC can be used to prove compliance (as is done with financial subsidies in several countries), which fosters higher quality of works. The implemented measures, as suggested by the BRP, will be more accurate and of higher quality (e.g. higher performance of the insulation material)[156].	
Cost-optimality	The BRP can display whether investing in energy performance or investing in renewable energy sources is the best option.	While this model focuses on single buildings, buildings managers might have a more cost-optimal pathway towards the end-goal.
	The audit or passport is written by an expert which helps avoid costly lock-in effects, ensuring that buildings can reach optimal performance by 2050 in a relatively cost-effective way.	Optimising the combination of energy efficiency and renewables on an individual building level, risk leading to the non-consideration of macro-economic costs (e.g. additional investments in the power infrastructure), which are not reflected in the microeconomic model for the individual building.

[156] Fabbri, et al. (2020). "Final report – Technical study on the possible introduction of optional building renovation passports". European Commission. (Available: Online)

Socio-economic		
Split incentives	The progressive MMR reduces the barrier of the split-incentive dilemma since the decision to invest in energy renovations is mandatory.	The actor bearing the cost to comply with the MMR might not be the same as the one getting the benefits. At worst, this could lead to a higher demolition rate or vacant apartments.
Energy poverty	Improving the worst-performing buildings, in which a larger share of energy-poor persons live, would reduce energy bills and improve health and wellbeing.	Without clear regulation, there is a risk the cost of the renovation measures will fully be put on the tenants (through rent increases), which then could have an adverse effect.
EU long-term targets		
2030 GHG milestone	This can force more efficient buildings to also play their role to achieve the 2030 milestone, not focusing solely on worst-performing buildings.	The impact until 2030 in terms of energy performance and carbon emissions will be limited, as the first step will be to acquire a building renovation passport.
Carbon neutrality by 2050	The model enables the contribution of each building to reach an average performance of the overall building stock	
Renewable s	The model fosters investments in renewables, which contributes to the renewable targets.	

Table 24. Impact assessment MMR Model 5

Illustrative impact assessment:

MMR model 5 consists of mandating the implementation of renovation packages identified in a BRP. BRPs are here assumed to consist of four renovation packages, three of which focus on the energy efficiency of the building envelope (assuming distributed energy savings across renovation packages) with the fourth one consisting of renovating to higher-efficiency and low-carbon heating systems.

This MMR model is considered to trigger earlier renovations thanks to the provision of quality information to households via the deployment of BRPs. However, assuming that retrofitting of the heating system is the last step in an ‘energy efficiency first’ renovation pathway, large GHG emission reductions are only obtained on the last part of the time horizon (corresponding to the mandatory implementation of the last renovation packages). This shows that low-carbon heat deployment should be seen in parallel to triggering the first renovation packages to reach ambitious 2030 GHG targets.

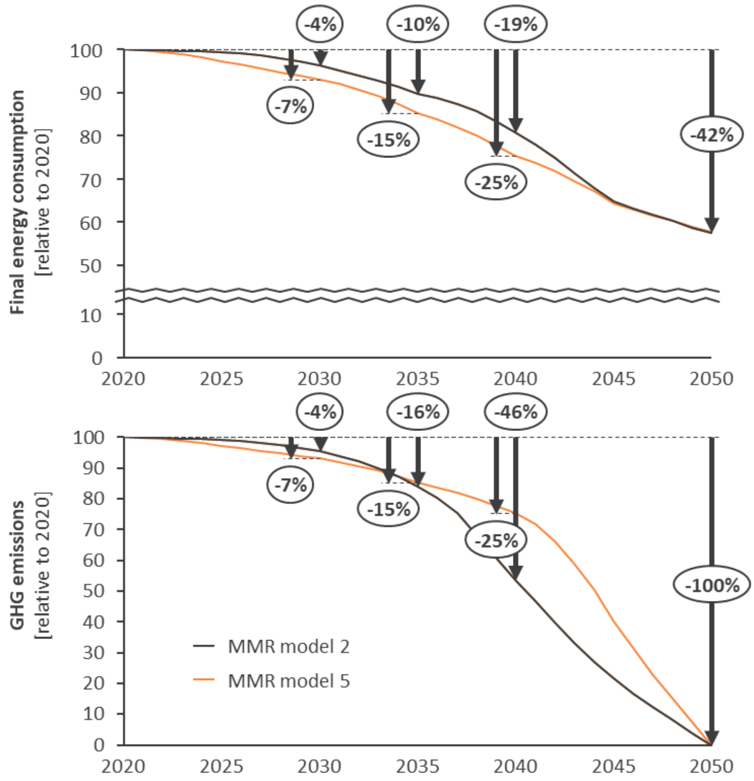

Figure 55 – Illustrative impact assessment of MMR model 5 on the French residential buildings stock

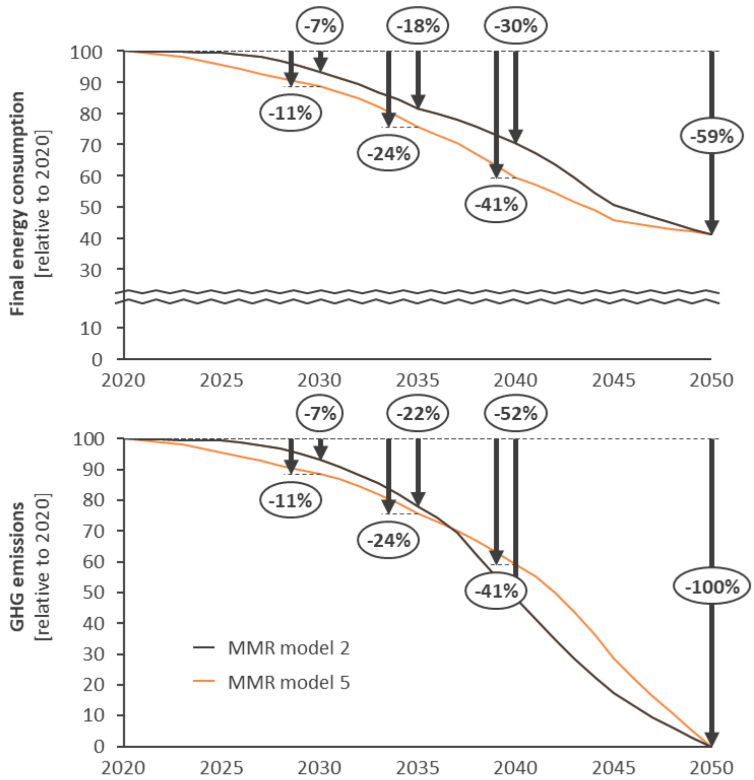

Figure 56 – Illustrative impact assessment of MMR model 5 on the German residential buildings stock

Feasibility analysis

Indicator	Strength	Weaknesses
Maturity of existing "infrastructure"	First experiences of BRP are available in several of the Member States (Germany, Belgium). Further, the instrument is already flanked within the EPBD.	A general, fair and adapted building passport is yet to be defined. Inspiration can be found in the already existing cases but must be greatly amended to be applied EU-wide.
Simplicity	The BRP could simplify and tailor the message to the end-user, increasing the acceptance.	Every building must be analysed by an expert which requires a high workforce that is not yet trained.
		The expert must be trained and unbiased, having no conflict of interests. Compliance mechanisms and guidelines are required to ensure high reliability.
Ease of compliance	Directly relates to the information about the step to implement and how much investment is needed. Proof of compliance can be ensured by the construction workers or through a purchase receipt.	

Table 25. Feasibility assessment MMR Model 5

11.6. MMR model 6: Mandatory renovation of all buildings at real estate transactions to move towards the long-term target

Impact consideration

Indicator	Strengths	Weaknesses
Techno-economic		
Renovation rate	Real estate transaction rates are about ~1.7%/year, indicating the potential of this model on the renovation rate.	
Renovation depth	Real estate transactions are the best moment to undertake a deep renovation. This MMR model captures these trigger points.	Progressive enforcement might trigger step-by-step renovations before one-stage deep renovations. If the progressive enforcement calendar is defined right away (i.e. what performance is required by 2050, including milestones) it would reduce this risk, as building owners and investors would also renovate to make their building asset "future proof" (i.e. not just complying with the pending requirement but the ones that will come into force in 10-20 years).
Renovation quality	The EPC can be used to prove post-measure compliance (as done with financial subsidies in several Member States), which fosters higher quality of works.	Operational (actual) energy use often differs from the theoretical energy use (asset rating). The current EPC frameworks are predominantly focused on theoretical energy use, which might lead to that the full scope of estimated energy savings might not materialise in actual energy savings.
Cost-optimality	Many buyers of buildings do carry out work in conjunction with the purchase. Embedding mandatory renovations can lead to relatively small additional costs while bringing savings on energy bills capturing most of the costs since real-estate transactions are usually long-term (>20 years)	To reach carbon neutrality, one-stage approaches are cheaper than multiple-staged ones. By default, MMR model 6 triggers staged renovations to comply with the progressively increasing requirement. This might then increase the total investment costs. While this model focuses on individual buildings, building managers might have a more cost-optimal pathway to the final target (e.g. deep renovation of 20% of their buildings every five years).
Socio-economic		
Split incentives	Addresses the split incentive by forcing owners at the time of their acquisition to improve the building.	Focuses only on single ownership as real estate transactions are less of an opportunity to structure deep renovation projects in multiple-ownership buildings.
Energy poverty	If not combined with an MMR model targeting the worst-performing buildings, this model would not be effective in improving these.	Risk of higher pressure on access to housing; acquiring a property causes indebtedness that could be increased further with mandatory renovation works.

EU long-term targets		
2030 GHG milestone	Mandating all building owners to renovate, when purchasing a new property. It would trigger renovations beyond the worst-performing buildings.	If not combined with an MMR model targeting the worst-performing buildings, this model would not be effective in improving these.
2050 carbon neutrality		The main focus on single-ownership buildings – additional actions are needed to decarbonise the remaining buildings.
Renewables		The focus on energy efficiency does not explicitly foster the development of renewable energy sources.

Table 26. Impact assessment Model 26

Illustrative impact assessment:

MMR model 6 is assumed to capture the 1.9%/year sales from 2025 onwards to trigger deep energy renovations. Beyond what is already triggered by MMR model 2, MMR model 6 fosters earlier and deeper energy renovations. It has the potential to increase the results reached by 2030, further reducing in the case of France the final energy consumption by between 6% (two-stage renovations) and 9% (one-stage renovations), and the GHG emissions by between 8% (two-stage renovations) and 20% (one-stage renovations) compared to 2020. Despite a similar annual rate of sales, additional savings by 2030 are higher for Germany as there is a higher share of worst-performing buildings.

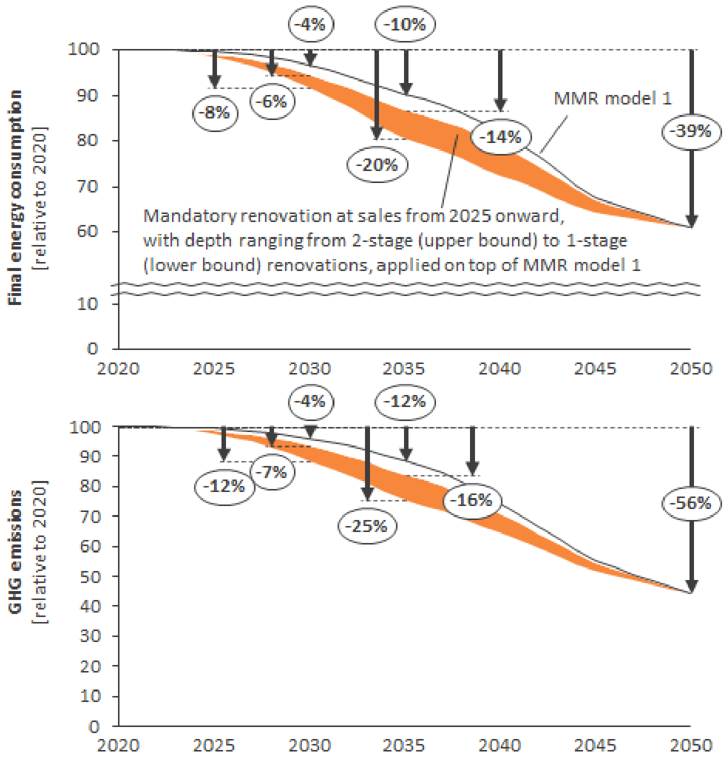

Figure 57 – Illustrative impact assessment of MMR model 6 on the French residential buildings stock

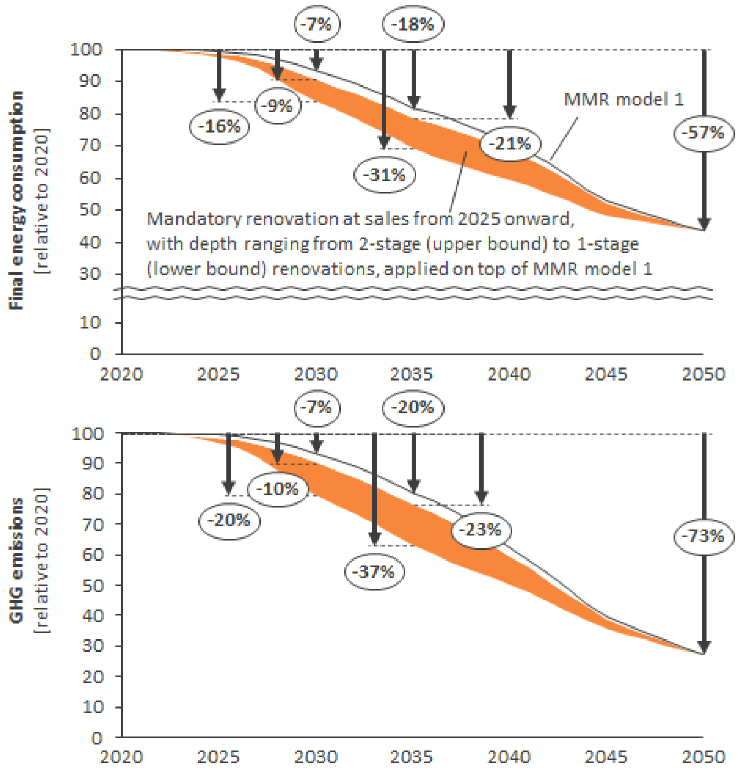

Figure 58 – Illustrative impact assessment of MMR model 6 on the German residential buildings stock

Feasibility analysis

Indicator	Strength	Weaknesses
Maturity of existing "infrastructure"	Including EPCs for transactions is already mandatory. Hence there is a great opportunity to add the necessary investments to reach the necessary energy performance level.	Most Member States have less than 10% of their building stock covered by EPCs. The **EPCs diverge in quality and reliability**, depending on the existing framework in place, including control mechanisms.
	The EPC infrastructure already exists, to different extents, in all Member States. The reliability of EPCs is improving and has a head start on any new instrument.	Public EPC databases are not in place in all countries so the quality of the gathered data differs between the Member States.
	Several Member States have robust EPC databases that can be used to check compliance.	
Simplicity	The MMR applies to all buildings (except the 2050-ready), which makes the provision simple to grasp. Easy for municipalities to keep track as property transfers generally are reported.	
Ease of compliance	Applies to real-estate transactions which allow easier and clear communication to ensure understanding and compliance from all parties.	Increases the necessary investment when buying new property and works may lead to unexpected additional costs or delay which not always viable (e.g. new business).

Table 27. Feasibility assessment MMR Model 6

11.7. Methodology for the illustrative impact consideration

The illustrative impact considerations are proposed to highlight the main features of MMR models, compared to each other. The modelling used CLIMACT tools, developed to design and evaluate buildings renovation scenarios in the context of the LTRS. The tool was refined to apply to the MMR models proposed in this report.

The quantification was performed on two Member States, Germany and France. The illustrative impact assessment focuses on residential buildings as data on the energy performance of non-residential buildings remain insufficient. This appendix provides the data sources considered and the assumptions made for this assessment.

The goal of this quantification is to provide a first illustration of the relative impacts from one MMR model to another. A list of assumptions is provided. The assumptions are a simplified version of reality and should be regarded as such. The modelling can certainly be refined in the future to better account for additional specific dynamics and variables. Also, only the direct (on-site) emissions are considered, i.e. emissions from the generation of electricity and lifecycle impacts are not accounted for.

The results can be very sensitive to some of these assumptions. Next steps to strengthen this quantitative assessment beyond the scope of this study should be: 1) identify the assumptions to which the results are the most sensitive, 2) collect data to strengthen these assumptions, 3) calibrate the modelling data to the reported energy consumption (in the absence of calibration the results are provided in relative terms).

11.7.1. General assumptions

The impact is driven by the distribution (initial and evolving) of buildings across EPC classes and their respective energy intensities.

Label	Share of residential buildings	Avg primary energy consumption [kWh/m²/y]	Share of residential buildings	Avg primary energy consumption [kWh/m²/y]
F	11%	653	56%	580
E	21%	305	12%	325
D	29%	210	13%	225
C	17%	135	10%	138
B	13%	80	4%	88
A	9%	38	5%	38

Table 28. Distribution of the residential buildings stock for France and Germany and average specific primary energy consumptions by EPC label considered in this assessment

- The long-term primary energy consumption target is set to 100kWh/m²/year. This seems a realistic target considering the long-term target currently defined in LTRS: 100kWh/m²/year in Flanders (Belgium), 85kWh/m²/year in Wallonia (Belgium), BBC (low energy building) level corresponding to 80kWh/m²/year in France.
- Robust calibration of the model to the national energy balances being beyond the scope of this project, results are provided in relative terms. The order of magnitude of the results is consistent with the one obtained with detailed calibration for the building stocks in Flanders and Wallonia. Their renovation strategies report that the renovation of their residential buildings stock will reduce the final energy consumption for heating (by 2050 in relative to 2020) by 25% in Flanders targeting 100kWh/m²/year and by 55% in Wallonia targeting 85kWh/m²/year.
- No differentiation of the average floor area is considered across EPC classes. Depending on the characteristics of the national buildings stock, proper

differentiation will modify the weight on the final results of energy renovations of the different segments.[157]

Label	Primary energy conversion factors
F	40%
E	55%
D	70%
C	85%
B	100%
A	100%

Table 29. Primary energy correction factors

- The GHG emissions are derived based on the following fuel mixes:

Energy carrier	Fuel mix considered by 2020[158]	Improved fuel mix by 2050 (MMR model 1)	Low carbon fuel mix by 2050 (MMR model 2)
Coal	0%	0%	0%
Oil	15%	0%	0%
Gas	46%	46%	0%
Electricity	8%	8%	10%
Sustainable energy resources	31%	46%	90%

Table 31. The fuel mix for heating modelled for France

Energy carrier	Fuel mix considered by 2020	Improved fuel mix by 2050 (MMR model 1)	Low carbon fuel mix by 2050 (MMR model 2)
Coal	1%	0%	0%
Oil	22%	0%	0%
Gas	50%	50%	0%
Electricity	2%	2%	10%
SER	25%	49%	90%

Table 32. The fuel mix for heating modelled for Germany

- GHG intensities are further derived for each EPC class considering that each improvement of one EPC class increases the share of low-carbon heat (including electricity) by 30%.
- A performance gap is often observed, resulting from non-optimal performances at different steps of the value chain (design, implementation, utilisation, maintenance). The possible impact of this performance gap is illustrated by considering that for high-efficiency buildings (< 50kWh/m²/year), the real energy consumption can be up to 25% higher than the one calculated ex-ante (this is a working assumption that can be refined).

11.7.2. Assumptions specific to MMR models

- Timing of implementation
    - In the modelling of MMR models 1 and 2, it is assumed that the announcement of a first mandatory minimum requirement applying

[157] E.g. data from the EPC databases in Belgium show that the floor area of today's best-performing dwellings is 17% (in Wallonia) and 23% (in Flanders) higher than the floor area of the worst-performing ones.

[158] Based on "Mapping and analyses of the current and future (2012, 2020, 2030) heating/cooling fuel deployment (fossil/renewables) -- Work package 3: Scenarios for heating & cooling demand and supply until 2020/2030"

  by 2035 will progressively accelerate the pace of renovations from 2025 onward to reach a steady-state activity by 2030.
  - Given that MMR model 5 requires the deployment of a BRP to households and considering that the quality of information helps to trigger renovations, MMR model 5 is modelled as leading to steady-state renovation activity from 2025 onward.
  - It is considered that every not-captured key moment is a missed opportunity to trigger energy renovations and that key moments should be captured as soon as possible to support the realisation of the 2030 GHG target. In the modelling of MMR model 6, it is assumed that key moments are progressively captured from now on to reach their full potential from 2025 onward.
- MMR model 2 formalises targets on the GHG emission intensities (i.e. $kgCO_2/m^2/year$). The modelling tools do not allow to model this as such. Two approaches were followed, both considering that carbon neutrality is set as long-term target:

  - On top of the final energy consumption reductions resulting from MMR model 1, a progressive deployment of low-carbon heating technologies is considered towards carbon neutrality. It is assumed that low-carbon technologies will be progressively deployed in better-performing buildings. The pace of deployment follows the evolution of the share of EPC B buildings in the buildings stock.
  - EPC level upgrades are expressed directly in terms of GHG intensity. To this end, the distribution of buildings across GHG intensity clusters is structured based on the EPC level distribution and the fuel mix as follows: given the buildings-related energy intensities and energy carrier-related GHG intensities, solid fuel-based dwellings 'lose' 2 EPC classes and gas-based dwellings 'lose' 1 EPC class. This increases the amount of worst-performing buildings which then leads to triggering the renovation of a higher amount of buildings by the first milestone (i.e. 2035 in this assessment).
  - The initial and targeted levels of GHG intensity provided in the table below were considered. While the values based on the theoretical energy consumption inform the link between EPC levels and the corresponding GHG intensities, those based on corrected energy consumption were considered to assess the GHG emission reductions resulting from the MMR model. There are slight deviations between the initial and targeted GHG intensities which should be read as follows e.g. for class E[159] buildings: current class E buildings have a GHG intensity of $24kgCO_2/m^2/year$, but class F buildings reaching class E after renovation has a GHG intensity of $20kgCO_2/m^2/year$.

[159] Class E buildings are – under this modelling approach to MMR model 2 – buildings with the average energy efficiency of EPC E buildings heated with gas-fired boilers or lower-carbon technologies. Coal-fired and oil-fired boilers are switched to class F.

		Initial GHG intensity [$kgCO_2/m^2$], based on		Targeted GHG intensity [$kgCO_2/m^2$], based on	
Class	Share of EPC revisited based on GHG intensities	Theoretical energy consumption	Corrected energy consumption	Theoretical energy consumption	Corrected energy consumption
F	16%	120	43		
E	23%	49	24	50	20
D	26%	29	18	25	15
C	16%	15	12	15	10
B	12%	7	6	5	5
A	7%	2	1	0	0

Table 33. GHG intensities considered for the French residential buildings stock

		Initial GHG intensity [$kgCO_2/m^2$], based on		Targeted GHG intensity [$kgCO_2/m^2$], based on	
Class	Share of EPC revisited based on GHG intensities	Theoretical energy consumption	Corrected energy consumption	Theoretical energy consumption	Corrected energy consumption
F	16%	106	41		
E	23%	54	29	50	20
D	26%	33	23	25	15
C	16%	17	14	15	10
B	12%	9	8	5	5
A	7%	2	2	0	0

Table 34. GHG intensities considered for the German residential buildings stock

- For MMR model 6, the yearly rate of sales of existing dwellings is considered to be 1.9%/year based on the following:

    - In France, there were 870,000 housing transactions a year on average during the last three years with available data[160], which represents an average yearly rate of 2.9%. Since we focus on existing buildings, the 1%[161] rate of new residential dwellings must be subtracted which leaves a 1.9%/year rate of housing transactions of existing units.
    - In Germany, there were 1,004,000 housing transactions a year on average in the last three years with available data[162], which represents an average yearly rate of 2.5%. Subtracting the 0.6%[163] rate of new residential dwellings leaves a 1.9%/year rate of housing transactions of existing units.

[160] European Central Bank – Statistical Data Warehouse (2017, 2016, 2015) (Available: Website)
[161] Zebra 2020 Porject. European Commission – Horizon 2020 (Available: Website)
[162] Arbeitskreis der Oberen Gutachterausschüsse, Zentralen Geschäftsstellen und Gutachterausschüsse in der
Bundesrepublik Deutschland (AK OGA) (2019) Figure 4-1 (Available: Online)
[163] Zebra 2020 Porject. European Commission – Horizon 2020 (Available: Website)

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