European Commission

INVESTORS DIALOGUE ON ENERGY

Financial instruments and models for heating and cooling

Disclaimer

The information and views set out in this study are those of the Investors Dialogue on Energy and do not necessarily reflect the official opinion of the Commission or individual Members of the Investors Dialogue on Energy. The Commission does not guarantee the accuracy of the data included in this study. Neither the Commission nor any person acting on the Commission's behalf may be held responsible for the use which may be made of the information contained therein.

EUROPEAN COMMISSION

Directorate-General for Energy
Directorate A — Energy Policy: Strategy and Coordination
Unit A.4 — Chief Economist

Contact: Julian Dieler

E-mail: julian.dieler@*ec.europa.eu*

European Commission
B-1049 Brussels

EUROPEAN COMMISSION

Financial instruments and models for heating and cooling

Investors Dialogue on Energy

Directorate-General for Energy
Investors Dialogue on Energy
2024

Manuscript completed in May 2024

PDF	ISBN 978-92-68-10996-0	doi: 10.2833/654652	Catalogue number: MJ-05-23-566-EN-N

Luxembourg: Publications Office of the European Union, 2024

Table of contents

List of acronyms

Acronym	
CEF	Connecting Europe Facility
CEC	Citizen Energy Community
CF	Cohesion Fund
CfD	Contract for Difference
DFI	Development Financial Institution
DG	Directorate General
DHC	District Heating and Cooling
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EE	Energy efficiency
EIB	European Investment Bank
EIC	European Innovation Council
EIF	European Investment Fund
ERDF	European Regional Development Fund
ESCO	Energy Service Company
ETS	Emission Trading System
EU	European Union
GBER	General Block Exemption Regulation
GDP	Gross Domestic Product
GHG	Greenhouse gas
H&C	Heating and Cooling
HHI	Herfindahl-Hirschman Index
HP	Heat Pump
ID-E	Investors Dialogue on Energy
IEA	International Energy Agency
JTM	Just Transition Mechanism
LCOE	Levelised Cost of Energy
MF	Modernisation Fund
NECP	National Energy and Climate Plan
NRRP	National Recovery and Resilience Plan
NZIA	Net-Zero Industry Act
PPA	Power Purchase Agreement
PV	Photovoltaic
RDI	Research, Development, and Innovation
RES	Renewable Energy Source
RRF	Recovery and Resilience Facility
SME	Small and medium-sized enterprise
T&D	Transmission and Distribution
TRL	Technology Readiness Level
UK	United Kingdom
UoP	Use of Proceeds
VPP	Virtual Power Plant
WACC	Weighted Average Cost of Capital

Executive summary

Heating and cooling is crucial for the successful achievement of Fit for 55 and REPowerEU targets and objectives. Achieving these goals necessitates the implementation of ambitious measures for the discontinuation of fossil fuel-based heating systems in all energy markets, but also the involvement of municipalities, citizens, businesses, and energy service companies.

Revenues in heating and cooling are driven by a number of factors, including the overall demand for heating and cooling services, the availability of energy sources, technological advancements, and government policies and incentives.

Investments in heating and cooling are affected by barriers of different nature, some stemming from market failures or citizens engagement, others from financial, technical or regulatory aspects.

Financial instruments can address some of the barriers to investment that are slowing down the decarbonisation of the EU energy sector. Through a range of instruments available at EU and Member State level, policy makers and investors can overcome some of the obstacles making energy projects, particularly innovative ones, too risky for the private sector alone. The presence of non-financial barriers affecting heating and cooling investments requires additional measures beyond financial instruments to create a truly enabling environment for heating and cooling investments.

A mapping of financial support schemes at Member State level resulted in the identification of 300 schemes available for heating and cooling in the 27 Member States. In line with other segments of the energy value chain, several trends can be observed in the offering of financial support schemes for heating and cooling:

- Loans and grants are the most used types of financial schemes;
- Just twelve schemes are designed specifically for heating and cooling only, whereas all the others target at least one more energy segment, and 171 schemes target all segments of the energy value chain;
- Most of the mapped instruments target mature and market-ready projects (“roll-out stage”), and only to a lesser extent – early stage and less mature technologies;
- SMEs and larger companies are the most supported category of beneficiaries of the mapped financial support schemes, but households received a higher support compared to other segments.

Four main factors were identified as key for a support scheme to be effective in the heating and cooling sector: a bigger ticket size obtained from aggregating multiple projects, easy application process with the possibility to apply all year around, low bureaucratic requirements, and long-term support.

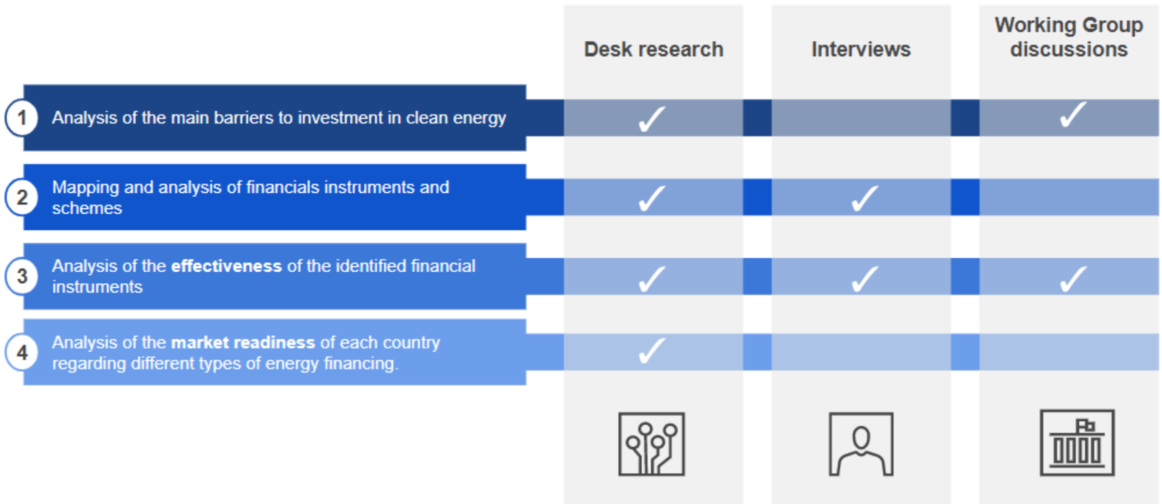
The availability of a comprehensive set of financial instruments for H&C is particularly important in countries with low market maturity and a big investment gap to address Renewable Energy Directive (RED) 2030 targets. In general, availability of private finance indicates a healthy financial system, while public financing should serve specific policy goals and address market failures, avoiding supporting mainly mature technologies

1. Introduction

The “Study on current energy sector investment instruments and schemes” in the Heating & Cooling (H&C) sector in the EU has been carried out as part of the Investors Dialogue on Energy – an initiative launched by the European Commission, DG ENER in 2022 as a multi-stakeholder platform bringing together experts from energy and finance sectors in all EU countries to assess and upgrade financing schemes to mobilise financing in the context of the European Green Deal and REPowerEU.

This study focuses on the heating and cooling sector and is the fourth of a series of studies which cover energy production, transmission and distribution, energy storage, and services and prosumers. The study has been prepared on the basis of research carried out in 2022 and beginning of 2023 and incorporates data collected via desk research and interviews, as well as feedback from stakeholders participating in the discussions of Working Group 4 of the Investors Dialogue for Energy, which focuses on heating and cooling (see Figure 1).

Figure 1: Overview of main topics and data sources



This study will set the basis for further work under the Investors Dialogue on Energy on the identification of new or upgraded solutions for financing the decarbonisation in H&C, in order to support the achievement of the EU’s 2030 climate and energy targets.

2. The investment context for Heating & Cooling

In 2019, EU leaders committed to achieving climate neutrality by 2050, following their commitments to the Paris Agreement. This chapter presents the potential contributions of various economic sectors in reducing greenhouse gas (GHG) emissions, the mechanisms used by the EU to reduce emissions from energy-intensive industries, and the challenges faced by Member States and regions in achieving climate neutrality by 2050. Additionally, the chapter highlights the importance of national decarbonisation strategies for heating and cooling to meet the EU's climate change mitigation targets.

2.1. The new macroeconomic conditions for energy investment

Over the last couple of years, Europe has experienced a period of profound macroeconomic and geopolitical change, characterised by often unpredictable events that have made it necessary to accelerate the energy transition process and to adapt funding flows to the evolving needs. The following four macroeconomic trends have been identified which will make the coming years, and the next Multiannual Financial Framework (MFF) budgeting period, fundamentally different than the past decade.

1. Tackling the climate crisis

At the end of 2019, the European Union published the European Green Deal[1], which outlined its aim to become the first climate-neutral, resource efficient, and sustainable economy by 2050. As an intermediate step towards climate neutrality, the EU strengthened its commitments to climate and energy, pledging to reduce 55% of net GHG emissions by 2030, while ensuring Europe's security of energy supply.

In 2022, CO_2 emissions from district heat production were 1.5% higher than in 2021 and about 25% higher than in 2010, due to growing demand. District heating currently represents almost 4% of global CO_2 emissions, with a significant contribution arising from China and, to a lesser extent, Russia. Europe is the third largest emitter, but on average it has a lower carbon intensity compared to the rest of the world. Over the past decade, the global average CO_2 intensity of district heat supplies has been increasing at about 0.4% per year, owing mostly to the development of new fossil fuel-based networks in China. Aligning with the NZE Scenario will require the CO_2 emissions intensity of district heat production to be at least 20% lower by 2030 compared with 2022. [2] In order to align current laws with the 2030 and 2050 ambitions, the Commission tabled the Fit for 55 package of legislative measures which, among other targets, proposed to increase the share of renewable energy sources in the overall energy mix from 32% to 40% to speed up the decarbonization of the energy system. These new and updated targets represent a major challenge and a necessary acceleration of green investments. The impact of these policy shifts is already being felt strongly in the European financial sector. Example of notable shifts include:

- The publication of the European Taxonomy, which provides companies, investors and policymakers with appropriate definitions for which economic activities can be considered environmentally sustainable, thus helping the EU to scale up sustainable investment and implement the European Green Deal. The aim of the Taxonomy Regulation is to boost investment in green projects by setting common definitions across the EU for what investments may be considered 'green', recognising potential

[1] The European Green Deal, *European Commission*, December 2019.

[2] District Heating, IEA.

of HVACR sector to contribute to climate change mitigation. Nuclear energy and natural gas are bound by strict criteria in the revised EU Taxonomy, for example, the production of heating and cooling from fossil gas in district heating is considered green if it produces emissions below 270g CO_2/kWh, and the thermal energy cannot be efficiently replaced by renewables for the same capacity.[3]

- The transformation of the EIB into the European Climate Bank, and the ensuing commitment to gradually increasing its share of finance dedicated to green investment to over 50% by 2025 and beyond.

The urgency of the climate crisis is increasingly reshaping the investment environment for energy production, with an ever-stronger focus on low carbon technologies.

One of the solutions appears to be the heat pump. Leveraging electricity to harness ambient heat from the ground, water or air, heat pumps can supply useful heat with one-third to one-fifth of the electricity used by conventional electric equipment. Considering national electricity generation portfolios for the year 2021, more than four-fifths of global space and water heating demand could be met with lower CO_2 emissions by using heat pumps instead of condensing gas boilers.

Thanks to continuing improvements in heat pump energy performance and reductions in the carbon intensity of power generation, this potential coverage is a major improvement from the 2010 level of 50%. Rapid reductions in emissions from electricity supply and increased technology efficiency in the Net Zero Scenario mean that in all regions, heat pumps would record lower CO_2 emissions than natural gas-fired condensing boilers before 2025.

2. *Ending the EU's dependence on Russian fossil fuels*

The energy crisis, intensified by Russia's unprovoked aggression in Ukraine in February 2022, has had a significant impact on the EU's energy system and the European financial sector. Turbulence in energy markets, the all-time high energy prices and the risk of supply shortages across the EU have further exposed the EU's over-reliance on Russian fossil fuels, highlighting the need to accelerate the green transition under the European Green Deal and to ensure a more secure, affordable, resilient, and independent energy system[4]. To respond to these hardships, in May 2022 the European Commission presented updated energy targets in the REPowerEU plan[5] and the emergency electricity market design interventions.

The REPowerEU plan, which aims to cut the EU's energy dependency on Russian gas well before 2030, confirms the EU's commitment to achieving the European Green Deal's long-term goal of climate neutrality by 2050 and fully implementing the Fit for 55 package, proposing to increase the headline 2030 target for renewables from 40% to 45%. Specifically, in the heating and cooling sector, the plan focuses on promoting the widespread installation and adoption of energy-efficient heat pumps.

According to the International Energy Agency (IEA), heat pumps play a crucial role in the decarbonization of the heating and cooling sector. They are considered a key technology for improving energy efficiency and reducing greenhouse gas emissions. The REPowerEU plan recognizes the potential of heat pumps in meeting the EU's clean energy objectives and aims to accelerate their deployment across residential, commercial, and industrial buildings. By prioritizing the installation of heat pumps, the EU aims to achieve multiple goals simultaneously. First, it aims to reduce the reliance on fossil fuels for heating and cooling purposes, thus contributing to the overall reduction of greenhouse gas emissions. Second, widespread heat pump deployment is expected to enhance energy efficiency in buildings,

[3] The EU Taxonomy Regulation: Background and Consequences, Solar Heat Europe, March 2022.

[4] Progress on competitiveness of clean energy technologies, *EU Commission,* November 2022.

[5] REPowerEU: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition, *European Commission*, May 2022.

leading to lower energy consumption and decreased energy costs for consumers and businesses.

Moreover, the plan emphasizes the importance of supporting research and development initiatives in the heat pump sector, fostering innovation, and driving down the costs of heat pump technologies. It also includes measures to enhance public awareness and understanding of the benefits of heat pumps, promoting their adoption on a broader scale.

Overall, the REPowerEU plan recognizes the significance of the heating and cooling sector in achieving climate targets and acknowledges the instrumental role heat pumps can play in advancing the EU's transition towards a more sustainable, low-carbon future.

Broadly speaking, the war and the publication of the REPowerEU and the European Taxonomy are reshaping the direction of financial flows. In particular, investments in gas-related projects are narrowly limited to projects which serve the objectives of the energy transitions. Examples of such projects may include directional changes to pipeline flows (e.g., establishing north-south pipeline connections), or the repurposing of gas infrastructure for transportation and storage of hydrogen.

3. Rising interest rates in an inflationary context

The global economy is confronting a challenging situation not witnessed for decades. Inflation is persistently high (annual energy inflation in the EU reached 27% in January 2022, although in the same period in the next year it was considerably lower, 16.6%) amidst increased economic and geopolitical uncertainties and disruptions to energy and commodity markets and supply chain bottlenecks have been caused by the COVID-19 pandemic and Russia’s ongoing invasion of Ukraine.

In years past, in the aftermath of the global financial crisis, central banks maintained low interest rates for extended periods of time, leading to a low-volatility environment and easy financial conditions that investors grew accustomed to. In the coming decade, rising interest rates mean that capital is more expensive, and harder to get to, which could prove especially daunting for nascent cleantech industries attempting to establish themselves on the market. This adverse impact of rising interest rates is likely to be compounded by the related phenomena of inflation and supply chain bottlenecks. This is why it is important to create a favourable financing environment that prevents the energy transition and the development of clean technologies from slowing down.

4. Rising global clean tech competition

Europe’s partners are increasingly introducing policies and stimulus programs to seize the net-zero industrial opportunities. The prime example of rising competition for global clean tech dominance is the US Inflation Reduction Act (US IRA), which will mobilize over USD 360bn by 2033. Japan, India, China, the UK and Canada have also put forward their own national programs to stimulate their own clean tech leadership. While competition is beneficial to the overall global climate race to net zero, the EU is also increasingly looking to cement its own positioning in the clean tech space and prevent the outflow of its own industrial champions overseas. Therefore, to facilitate the reaching of its climate objectives and enable the necessary greening and competitiveness of EU industry, in January 2023 the Commission put forward the Green Deal Industrial Plan[6]. This plan will enable the EU to access key technologies, products, and solutions needed for a successful transition to net-zero, which will in turn boost economic growth and generate quality jobs. The Green Deal Industrial Plan will thus attract investments in the net-zero industrial base, with a focus on innovative

[6] A Green Deal Industrial Plan for the Net-Zero Age, *EU Commission,* February 2023.

technologies, helping them to overcome the so-called 'valley of death' before commercialisation[7].

In practice, reaching ambitious decarbonization targets and decoupling emissions from economic growth will require a fundamental transformation of the EU economy and, particularly, its energy system. The key buildings blocks of the transformation of the European energy context will consist of a range of measures, including those described in the following paragraphs

5. *Innovative systems of district heating are emerging*

Greater **heat source diversification** (especially shifting from fossil fuels to renewables, electricity and excess heat) and the integration of both large-scale and decentralised consumer heat pumps will propel the transition towards lower-temperature and more flexible district heating networks – a progression from third-generation to what is called fourth-generation district heating, and alternatively, the electricity-based and decentralised fifth generation innovations are principally related to:

- Heat can be recovered from several **secondary sources** such as data centres[8], metro tunnels, industry, electrolysers, nuclear power plants, directly or supported by heat pumps and storage systems. In 2022 in Canada, a waste heat district heating system was launched, to be fully operational by 2034[9]. In Lund, Sweden, the first phase of the largest low-temperature district heating system from surplus heat was inaugurated in 2019[10] and is expected to expand over the coming years with a plan up to 2035.
- Several innovations are advancing with **integration of renewables, heat pumps and thermal storage systems**, towards low-temperature district heating systems, such as the development of new deep geothermal solutions that do not require a permeable aquifer[11].
- Germany, District LAB[12] is opened to provide an experimental facility for district **heating network components**, as well as operational models.
- In Austria a world first-of-its-kind green hydrogen admixture trial has begun at a commercially used combined-cycle gas turbine plant[13] which provides 73 000 households with district heating.

The Global District Energy Climate Award has been in place since 2009 to identify best practices and innovations in district energy, and the last edition in 2021 nominated seven winners. The winners of the 2023 edition were announced on 14th November[14]. The annual International DHC+ Student Awards[15] (launched in 2012) highlight outstanding and original contributions to district heating and cooling-related research, including economic and technological aspects, energy management and the environmental consequences of energy utilisation.

2.2. Policy framework for Heating and Cooling

EU has implemented a range of policies and measures designed to promote energy efficiency and foster the use of renewable energy sources within the heating and cooling sector.

---

7 Questions and Answers: Green Deal Industrial Plan for the Net-Zero Age, *EU Commission,* 2023.

8 Utilize waste heat from data centres in district heating https://www.compute.dtu.dk/

9 CBE NEWS - Canadian communities are tapping into greener ways to heat and cool buildings

10 Low temperature district heating grid in Brunnshög, Lund environdec.com

11 Analysis – IEA Low-temperature district heating: heating our homes at lower cost

12 Range of services of the test facility District LAB District LAB (fraunhofer.de)

13 SIEMENS What the world could learn from Austria's first hydrogen field tests Donaustadt hydrogen trial (siemens-energy.com)

14 Global District Energy Climate Awards districtenergyaward.org

15 DHC+ student awards 11th international DHC+ student awards - Euroheat & Power

The 2016 **EU Heating and Cooling Strategy**[16] provided a first overview of the energy consumption and fuel mix of the heating and cooling sector in the main end-use sectors: buildings and industry. It also set out actions and tools to ensure that the heating and cooling sector contributes to the EU objective of climate neutrality by 2050. These actions and tools, which were implemented in the Clean Energy for all Europeans' package[17] adopted in 2019, relate to increasing renewable energy and energy efficiency in this sector, while applying in parallel an integrated approach to the energy system.

In March 2023, the European Commission agreed to reinforce the **EU Renewable Energy Directive** and introduced the revised Directive EU/2023/2413 in November 2023. It brings the EU one step closer to completing the "Fit for 55" legislation to deliver the European Green Deal and the REPowerEU objectives. **RED III**[18] **raises the EU's binding renewable target for 2030 to a minimum of 42.5%,** up from the current 32% target and almost doubling the existing share of renewable energy in the EU, but **aiming at reaching 45% of renewables by 2030**. The RED III Directive includes targets and measures to support the uptake of renewables across various sectors of the economy. It strengthens **annual renewables targets for the heating and cooling sector** and for renewable energy used in district heating systems. It introduces a specific renewable energy benchmark of **49% for energy consumption in buildings by 2030** to complement EU buildings legislation and guide Member States' efforts. The indicative share of renewable energy in the building sector also promotes renewable energy investments in long-term national building renovation strategies and plans, thereby enabling the achievement of the decarbonisation of buildings. Moreover, renewable targets for heating and cooling will gradually increase, with a **binding increase of 0.8% per year at national level until 2026 and 1.1% from 2026 to 2030**. The minimum annual average rate applicable to all member states is complemented by additional indicative increases calculated specifically for each member state.

Another notable example includes **Energy Efficiency Directive (EU/2023/1791)**[19] which establishes 'energy efficiency first' as a fundamental principle of EU energy policy, giving it legal standing for the first time. In practical terms, this means that energy efficiency must be considered by EU countries in all relevant policy and major investment decisions taken in the energy and non-energy sectors. The directive raises the EU energy efficiency target, making it binding for EU countries to collectively ensure an **additional 11.7% reduction in energy consumption by 2030**.

Furthermore, there are several initiatives that represents a strategic effort to leverage advanced heating technologies to reduce the EU's carbon emissions, improve energy efficiency, and move towards a more sustainable energy future.

- **The REPowerEU Plan sets ambitious targets for the installation of heat pumps, with around 20 million to be installed in the EU by 2026 and nearly 60 million by 2030**[20]. The plan also encourages Member States to accelerate the deployment and integration of large-scale heat pumps in a cost-effective way. The REPowerEU Communication of March 2022 also includes the target of adding a total of 30 million hydronic heat pumps by 2030.
- The **Gas Package** initiative is a component of the overarching strategy aimed at reducing greenhouse gas emissions. It comprises a set of legislations intended to facilitate the transition of the gas sector towards renewable and low-carbon gases, with a particular focus on biomethane and hydrogen. The European Parliament has

[16] EUR-Lex - 52016DC0051 - EN - EUR-Lex (europa.eu)

[17] Clean energy for all Europeans package (europa.eu)

[18] Renewable energy: Council adopts new rules - Consilium (europa.eu)

[19] Directive - 2023/1791 - EN - EUR-Lex (europa.eu)

[20] European Parliament, The European Council, The Council, The European Economic And Social Committee And The Committee Of The Regions- REPowerEU Plan Link

officially approved a binding target of 35 billion cubic meters (bcm) for biomethane within the Gas Package. This target is poised to make a substantial contribution to supply security by replacing 20% of the imported natural gas volumes from Russia [21].

- **The Energy Performance of Buildings Directive (EPBD)** also plays a pivotal role in steering the EU towards a fully decarbonized building stock by 2050[22]. This legislative framework aims to promote highly energy-efficient and environmentally sustainable buildings. A key aspect of the directive involves the phased elimination of fossil fuel heating systems in households, with a preference for accomplishing this by 2035 and no later than 2040. Additionally, the directive allows for solutions such as hydrogen-ready boilers, utilizing biofuels, hydrogen, or a combination of fossil and renewable gases.

To assist policymakers developing new legislative initiatives and ensure the implementation with the help of sound evidence base, the Commission conducted a series of studies on the heating and cooling sectors. The following were published in June 2022[23]:

- A study on renewable space heating[24] presents a comprehensive overview of consumption data, technologies, fuel mix and regulatory frameworks, includes best practices for renewable energy communities, while also modelling possible decarbonisation pathways.
- A study on district heating and cooling [25] provides an overview of market and regulatory frameworks and presents ten case studies on best practices to illustrate successful models to integrate renewable energy and waste heat sources into thermal networks.
- A study on a roadmap on policy support for heating and cooling decarbonisation [26] sets out a heat decarbonisation roadmap and recommendations for policies covering space heating in buildings and process heating industry, while also including a meta-study on key literature.
- A study on renewable cooling[27] provides a comprehensive background analysis for the Delegated Act on the methodology to account renewable energy used in cooling and district cooling adopted on 14 December 2021.

Furthermore, publications such as: “Renewable Heating and Cooling Pathways”, “Electrification of Space Heating in Buildings”, both published in November 2023, “Advancing District Heating & Cooling Solutions and Uptake in European Cities” published in March 2023, or “A Study on a Roadmap on Policy Support for Heating and Cooling Decarbonisation” published in June 2022, contribute to the discourse on heating and cooling decarbonisation.

---

[21] European Biogas Association (EBA) - European Parliament endorses 35 bcm binding target for biomethane in EU Gas Package Link

[22] Directorate-General for Energy – Energy Performance of Buildings Directive Link

[23] European Commission (europa.eu) New studies look closer at decarbonising heating and cooling sector

[24] Directorate-General for Energy (European Commission) Report on Renewable space heating under the revised Renewable Energy Directive ENER/C1/2018-494 Link https://op.europa.eu/en/publication-detail/-/publication/16710ac3-eac0-11ec-a534-01aa75ed71a1/language-en

[25] Overview of markets and regulatory frameworks under the revised Renewable Energy Directive Linkhttps://energy.ec.europa.eu/district-heating-and-cooling-european-union_en

[26] Directorate-General for Energy (European Commission) Policy support for heating and cooling decarbonisation: Roadmap Link https://op.europa.eu/en/publication-detail/-/publication/f5118ffc-eabd-11ec-a534-01aa75ed71a1/language-en

[27] Directorate-General for Energy (European Commission) Renewable cooling under the revised Renewable Energy Directive Linkhttps://energy.ec.europa.eu/renewable-cooling-under-revised-renewable-energy-directive_en

2.3. End-use sectors of Heating and Cooling

Energy for heating and cooling represents almost 50% of the EU's total gross final energy consumption[28], being supplied 75% by fossil fuels[29]. This heavy reliance on fossil fuels poses significant economic and environmental implications. As a result, changing this sector towards the use of renewable energy can make an important contribution to decarbonising the energy system, as well as reaching the EU's energy and climate objectives for 2023 and consequently, the target to become climate-neutral by 2050.**The main heating and cooling end-use sectors are buildings and industry**. The building sector includes cooking, water heating, space heating, ambient cooling and refrigeration, while in industry, process heating (from low-temperature applications to high-temperature applications) and process steam are the main applications.

In the EU, heating for buildings constitutes a substantial portion of the overall energy consumption for heating and cooling. **In the residential sector, around 80% of the final energy consumption is used for space and water heating[30].** Additionally, industrial heat demand contributes to about one-third of the heating and cooling requirements. The remaining energy is utilized in agricultural activities and cooling applications[31].

Despite the COVID-19 pandemic leading to a decrease in industrial activity, and a milder winter reducing heating demands in European buildings, the residential and industrial heating and cooling needs in 2020 were only 10% lower than the average annual level recorded between 2005 and 2009[22] This observation highlights the **slow progress in achieving sustainable reductions in heating and cooling demand**.

End-use sector 1: Buildings

According to Eurostat, the main use of energy by households in the EU in 2021 was for heating their homes (64.4% of final energy consumption in the residential sector), followed by lighting and electrical appliances (13.6%), water heating (14.5%), cooking (6%), and space cooling (0.5%)[32]. Natural gas and oil products have traditionally been primary sources of energy for heating in residential buildings. However, electricity, biomass, waste heat recovery, and district heating systems are gaining prominence, offering efficient and low-carbon options for space heating and cooling. In 2020, space and water heating constituted 80% of all household energy use. Of this heating energy, more than half (57%) was supplied by direct domestic high-temperature heating systems that burned fossil fuels, including gas (39%), oil (15%), and coal (4%).

Although residential cooling currently constitutes less than 1% of the overall energy consumed[22] in the European Union for heating and cooling buildings, **rising average temperatures across the EU are projected to spur an increase in cooling demand and a decrease in winter-related heating**. From 2012 to 2021, the average land temperature across Europe was nearly 2°C higher than the pre-industrial level, underscoring the magnitude of the temperature rise[22].

Most EU countries possess large stocks of old and energy-inefficient buildings, which necessitate the use of high-temperature heating systems to compensate for substantial heat

[28] Heating and cooling from renewables gradually increasing - Products Eurostat News - Eurostat (europa.eu) Link

[29] Konstantinos Kavvadias et al. Electrifying the heating sector in Europe: The impact on the power sector, Proceedings Of Ecos 2019 - The 32nd International Conference On Efficiency, Cost, Optimization, Simulation And Environmental Impact Of Energy Systems June 23-28, 2019, Wroclaw, Poland Link

[30] EC- Heat pumps- Heat pumps - European Commission (europa.eu)

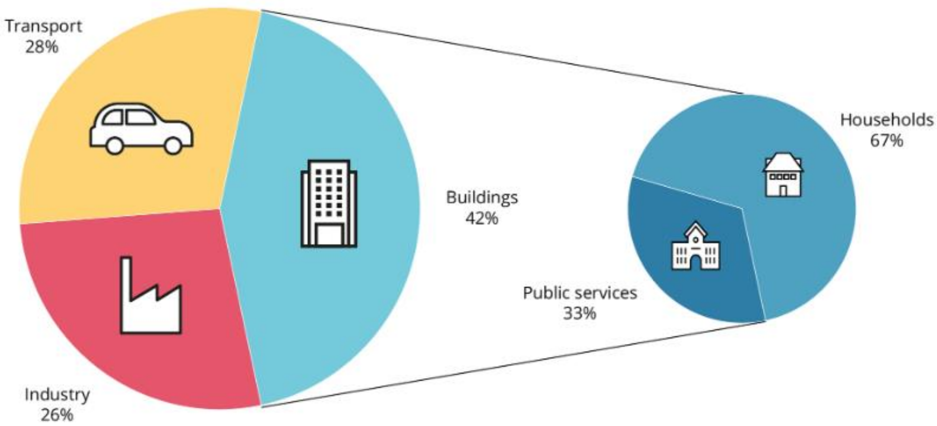
[31] Decarbonising heating and cooling — a climate imperative Link

[32] Final energy uses across EU households, with space and water heating disaggregated by fuel (2020) — European Environment Agency (europa.eu) Link

losses. In 2020, buildings accounted for more than two-fifths (42%) of all final energy consumed by all sectors[22], thereby making them a major source of greenhouse gas emissions. Households accounted for two-thirds of this energy consumption, as depicted in Figure 2. Historically, efficiency improvements in buildings have often coincided with increased heat and electricity usage, owing to factors such as larger building sizes, reduced energy prices, growing demand for cooling, and prolonged use of electrical equipment. In some cases, these increases have negated the benefits of enhanced energy efficiency. Nevertheless, across the EU, the average energy consumption per household has slightly decreased since reaching a peak in 2010, indicating that energy efficiency efforts are yielding results.

Figure 2: Final energy consumption by end-use sector, EU, 2020

Source: ESTAT, 2022 [33]



District heating, where heat (usually hot water) and electricity are produced industrially in larger systems and distributed via grids for domestic heating, supplies approximately 10% of the EU's heat and is prevalent in northern, central, and eastern countries. Fossil fuels in district heating contributed over two-thirds (69%) of all fuels combusted in combined heat and power plants and heat-only plants in 2020[22].

Electricity is one of the fastest-growing renewable energy sources for heating and cooling in Europe. It can be used directly through heat pumps or indirectly through appliances such as radiators or boilers. Electricity can also be combined with other renewable sources such as solar thermal or geothermal to provide low-temperature heat or process heat[22]. On another hand, electricity has a low share of renewable content (only 23% in 2020) but also a high share of variable content depending on the time of day and season[34]. Biomass is another renewable energy source that can be used for heating and cooling in buildings by means of burning it directly or being converted into biofuels such as biogas or bio-oil. Biomass can also be used to produce heat through processes such as gasification, pyrolysis, or anaerobic digestion. However, biomass has a lower share of renewable content than electricity (9% in 2020) but also a lower share of variable content[24].

Heat pumps, utilizing ambient heat from the air, ground, or water, are becoming increasingly popular due to their energy efficiency and environmental benefits[21]. Solar thermal systems, harnessing energy from the sun to provide heating and hot water, are also contributing to the diversification of the energy mix in residential buildings. The dynamics of

[33] EEA, Final energy consumption by end-use sector, EU27, 2020- ESTAT (2022).

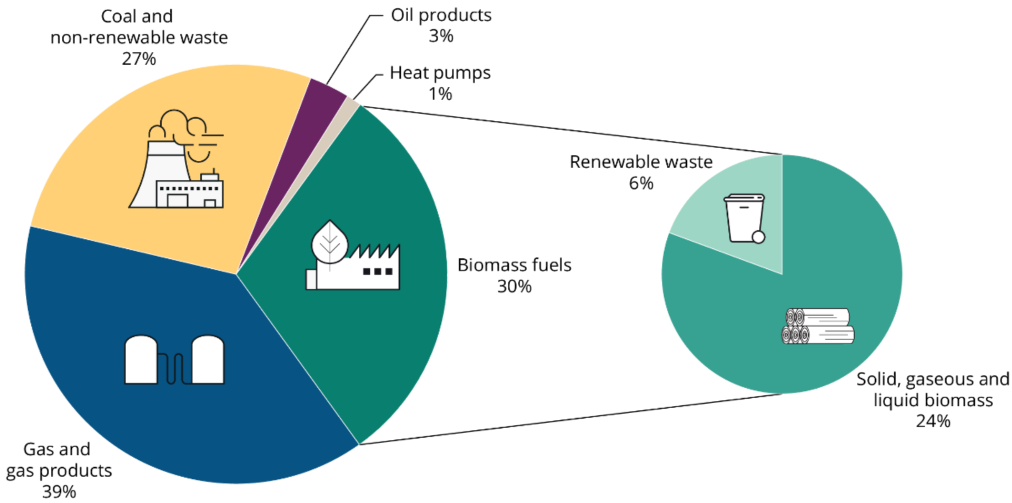
[34] European Technology Platform on Renewable Heating and Cooling (RHC-Platform) 2020-2030-2050, common vision for the renewable heating and cooling sector in Europe Link

the buildings sector are influenced by urbanization, population growth, income levels, consumer preferences, and regulatory frameworks. Urbanization trends, for instance, impact the density and type of buildings, affecting energy consumption patterns. Population growth contributes to an increased demand for housing and, consequently, greater energy requirements. Income levels influence the adoption of energy-efficient technologies, while consumer preferences play a role in shaping the market for sustainable heating and cooling solutions. Moreover, building standards and regulations exert a profound influence on the trajectory of the residential sector. Stringent energy performance standards and the integration of renewable energy requirements in building codes drive the uptake of innovative and sustainable technologies. These regulatory frameworks act as catalysts for the adoption of energy-efficient systems and contribute to the overall reduction of the environmental footprint of the residential buildings sector.

End-use sector 2: Industry

The industrial sector is a significant consumer of heat energy, accounting for a quarter of final energy use in the EU and using primarily fossil fuels as a source of energy (see Figure 3). It encompasses expansive facilities including factories, power plants, and data centres, all of which necessitate highly efficient and robust heating and cooling systems to ensure optimal operational performance and safety. Industrial heat demand makes up approximately one third of the overall EU heating needs.

Figure 3: Final energy uses across EU households, with space and water heating disaggregated by fuel type, 2020.



Source: ESTAT, 2022[35]

Technologies employed in the industrial sector include natural gas, oil products, electricity, biomass, waste heat recovery, district heating/cooling (DHC), heat pumps (HP), and steam turbines (ST)[22]. Notably, industrial activity levels serve as a fundamental factor influencing the energy demand and utilization within this sector. The pursuit of energy efficiency measures (EEMs) becomes imperative, driven by both economic considerations and the broader societal goal of reducing environmental impact. Although energy statistics do not provide a complete and consistent picture of final energy consumption for heating and cooling by end-use sector

[35] Gross EU heat production by fuel in CHP and district heating plants, 2020, [ESTAT (2022)]

and energy source[36], industrial processes require energy for both heating and cooling. This ranges from high-temperature heat required in metallurgical and ceramic industries to the use of lower temperature steam and cooling agents in food and textile industries.

Trends in the H&C market

The trends in the heating and cooling market in the EU are dynamic and multifaceted, propelled by scientific and societal considerations. Increasing urbanization and industrialization contribute to shifts in energy consumption patterns, with a growing need for advanced and sustainable heating and cooling solutions. Ongoing technological innovations and digitalization efforts, grounded in scientific research, further advance the capabilities and efficiency of heating and cooling technologies within the industrial sector.

Some of the upcoming trends[37] in the heating and cooling market in Europe, applicable to both the residential and the industrial sector, are:

- **Smart thermostats**: devices that can automatically adjust the temperature settings based on the user's preferences or external conditions such as weather or occupancy. For home applications, smart thermostats can control temperatures based on occupancy and preferences, via applications or voice commands for energy efficiency and comfort. In industries, advanced temperature control systems manage large spaces, regulating heating or cooling based on occupancy and production needs, ensuring stable conditions while minimizing energy usage.
- **Energy efficiency advancements**: In both residential and industrial contexts, improvements in the design or operation of heating and cooling systems that can reduce their energy consumption or emissions without compromising their functionality or comfort. Some examples are variable refrigerant flow (VRF) systems, heat pumps, geothermal systems, etc.
- **Hybrid systems**: heating and cooling systems that combine different modes of operation to provide optimal comfort levels for different seasons or activities. This trend is influenced by the changing preferences and behaviours of consumers who seek more flexibility, convenience, and personalization in their heating and cooling choices. Some examples of hybrid systems are multi-split systems that can switch between heating and cooling modes depending on the temperature setting or occupancy status.
- **Internet of Things (IoT):** network of interconnected devices that can communicate with each other or with a central server to exchange data or commands. In a residential setting, the Internet of Things (IoT) can be exemplified through a smart home system. For instance, IoT-enabled thermostats, lighting systems, and security cameras can communicate with each other and with a central hub. These devices gather data on temperature, lighting usage, and security status, allowing homeowners to remotely monitor and control these aspects via their smartphones or voice assistants. In an industrial setting, IoT can be integrated into a manufacturing facility for heating and cooling control. IoT sensors installed in machinery and environmental controls can communicate with a central system. These sensors collect data on temperature, humidity, and equipment performance, allowing for real-time monitoring and adjustments.
- **Machine learning**[38]: can be applied to optimize the performance of heating and cooling systems by detecting faults or anomalies. Machine learning techniques can be

[36] EC, 2022a, Commission Staff Working Document 'Implementing the REPower EU action plan: investment needs, hydrogen accelerator and achieving the bio-methane targets' (SWD(2022) 230 final).

[37] Heating, Ventilation, and Cooling System Market Size [2023-2030] by fortunebusinessinsights.com, Link

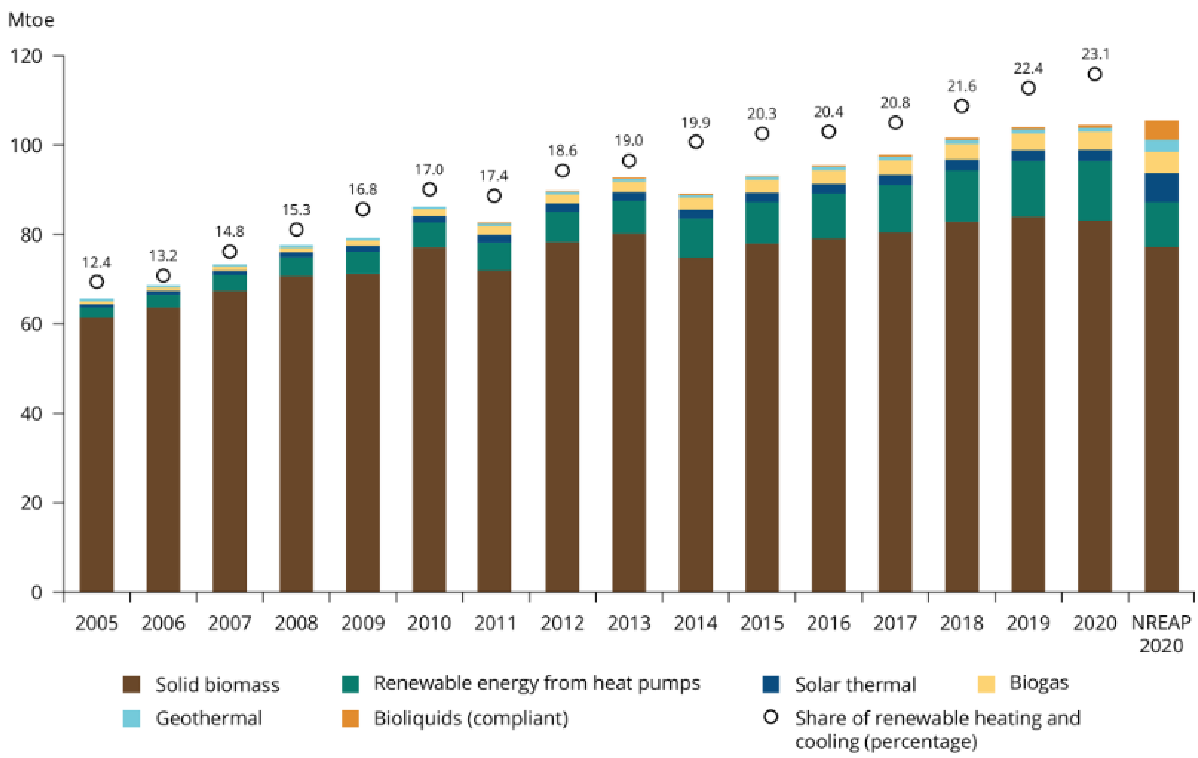
[38] Ntakolia, C., Anagnostis, A., Moustakidis, S. et al. Machine learning applied on the district heating and cooling sector: a review. Energy Syst 13, 1–30 (2022). Link

implemented into two main categories: (i) heating load/demand prediction (can be applied to both residential and industrial buildings) and (ii) design, maintenance and scheduling (more relevant to industrial sector. However, it can also be applied to residential buildings for optimizing the performance of HVAC systems).

Renewable energy sources in heating and cooling

As of 2020, renewable energy sources made up only 23% of the final energy used for heating and cooling across the EU[39]. Although this is a relatively small percentage, the absolute amount of renewable energy used for heating and cooling is substantial due to the high demand for these services. In the past five years, the growth rate of renewable energy use for heating and cooling has slowed down compared to the period from 2005 to 2015[22]. Despite this slower growth rate, the EU's share of renewable energy used for heating and cooling in 2020 was slightly higher than the 22.4% target[22] set by Member States in their national renewable energy action plans in 2010 (as shown in Figure 4). It is important to note that official statistics do not provide a comprehensive and consistent account of renewable energy consumption for heating and cooling per sector and energy source.

Figure 4: Historical use of renewable sources for heating and cooling in the EU, 2005-2020, and 2020 NREAP levels



Source: EEA renewable energy data viewer.[40]

[39] Renewables steadily increasing in heating and cooling [Products Eurostat News - Eurostat (europa.eu)]

[40] EEA renewable energy data viewer- [Member States' national renewable energy action plans (NREAPs)].

The analysis of trends in renewable energy sources for heating and cooling in different end-use sectors reveals two significant findings. Firstly, **solid biomass has emerged as the dominant heating fuel**, with its use for this purpose rising by more than a third since 2005, and accounting for 80% of all renewable energy utilized for heating and cooling at the EU level in 2020[22]. However, a considerable amount of this biomass was consumed by households using domestic heat stoves, which may lead to human exposure to air pollutants and have negative impacts on land carbon sequestration and biodiversity. Secondly, since 2005, **other renewable technologies for heating and cooling, including heat pumps and solar thermal collectors, have grown at a much faster rate than solid biomass**[22]. This suggests the potential for accelerated deployment of these technologies during the current decade.

District Heating Networks and Renewable Energy Integration

In 2021, the global amount of heat produced for district heating networks reached nearly 16 EJ (exajoules), showing a significant increase of approximately 10% compared to a decade earlier. Despite this growth, district heating still accounted for only about 8% of total final heat consumption worldwide. Fossil fuels, mainly coal (over 45%) in China, natural gas (about 40%) in Russia, and oil (3.5%), dominated the district heating production, representing almost 90% of the global district heat generation in 2021, down just by 5% from 95% in 2000[41].

Renewables, on the other hand, constituted less than 8% of global district heat supplies in 2021[42]. Bioenergy and municipal waste were the primary contributors to renewable district heating, with limited representation from large-scale solar thermal systems and heat pumps. By the end of 2021, approximately 300 solar district heating systems[43] with a combined capacity of 1.6 GWh were operational worldwide. Europe was leading the way in integrating renewables into district heating, with around 25% of its district heat supplies being produced from renewable sources. Notably, countries like Sweden, Denmark, Austria, Estonia, Lithuania and Latvia stood out with more than 50% of their district heat sourced from renewables[36.]

In the International Energy Agency's "Net Zero Emission by 2050", district heating is expected to maintain a similar share of global final heat consumption[36]. Energy efficiency improvements in district heating networks and building envelopes will contribute to an increase of efficiency in networks and a reduction of heat demand by around 20% compared to 2021 by the year 2030. However, during the same period, renewable energy utilisation in district networks is projected to nearly double, with renewable sources, including renewable electricity, accounting for almost one-fifth of district heating supplies by 2030[36.]. Below some examples of rapidly growing renewable energy sources used in H&C are presented.

Solar Heating Systems

In 2021, 44 new large-scale solar heating systems were constructed worldwide, with a total capacity of 142 MWth[36.]. Denmark used to host the largest solar thermal district heating capacity, but following a policy change, since 2020 there has been limited new solar district plant developments. The majority of global market growth in solar thermal district heating in 2021 occurred in China, which represented three-quarters of the global market[36].

Geothermal Heating and Cooling

---

[41] District Heating - Energy System – IEA link

[42] IEA - Renewables – Global Energy Review 2021 Link

[43] District Heating - Urban district networks - Reinva

In 2021, Europe saw the announcement of 13 new geothermal heating and cooling plants connected to district heating systems[36]. In Aarhus, Denmark, the development of Europe's largest geothermal district heating facility was announced at the beginning of 2022 and is expected to be partially operational by 2025[36]. Similarly, in Iceland, a local heating utility introduced new geothermal district heating to replace electric heating, offering subsidies to those connected to the system and the utility company.

Waste Heat Recovery

Projects integrating secondary heat sources, such as waste heat recovery, are gaining momentum. In Vienna, Austria, an energy company launched a heat-recycling program in 2022 that utilizes warm water (30°C) from local thermal baths with the help of a heat pump[36]. Another notable example from Austria is the district heating system that exports waste heat from Interxion's data centre to the neighbouring Floridsdorf Hospital in Vienna, a project that receives €3.5 million in subsidies from the Austrian federal government[36]. In Ireland, construction began in May 2021 on the country's first large-scale district heating network known as the Tallaght District Heating Scheme, which harnesses waste heat from a local data centre to provide heating for various public, residential, and commercial buildings in the Tallaght town centre area.

Large scale heat pumps

Sweden is one of the pioneers and leaders in the use of large-scale heat pumps for both district heating and district cooling. According to a study by Aalborg University[44], Sweden has more than 50 large-scale heat pump units installed, with a total capacity of 1.5 GWth, covering 8% of the total district heating supply and 40% of the total district cooling supply. For instance, the cooling centre at Potsdamer Platz in Berlin, which uses a high-temperature industrial heat pump manufactured by Siemens Energy, with a thermal capacity of 10 MWth and a maximum temperature of 150 °C. This heat pump uses the waste heat from the groundwater to generate cooling for the Potsdamer Platz buildings and heat for the district heating network[45].

In conclusion, **the global district heating market is experiencing growth, with renewable energy integration playing a crucial role in reducing reliance on fossil fuels**. Countries in Europe, especially Sweden, Denmark, Austria, Estonia, Lithuania, Latvia, and Iceland, are **leading the way in adopting renewables for district heating**. **Geothermal and solar thermal systems** are gaining traction, while **waste heat recovery projects** are becoming more prevalent. With the Net Zero Scenario in mind, the **district heating sector** is expected to witness **further advancements in energy efficiency and increased utilization of renewable energy sources by 2030**.

Prospects and challenges for the decarbonisation of H&C

Achieving net-zero targets is an important challenge in the H&C sector, given the complexity involving upfront fixed costs, diverse technology options, and regional variations. The demands vary across economic sectors, introducing further complexity, including factors like network infrastructure and building efficiency[46].

The EU and its Member States face a significant hurdle in decarbonizing heating and cooling due to the aging infrastructure of urban district heating systems, particularly in central and eastern Europe. These systems exhibit inefficiencies, high network losses, and a heavy reliance on fossil fuels. Overcoming this challenge requires complex and costly upgrades, involving the modernization of boilers, heat exchangers, heat supply networks, and system

[44] Neves J. et al Heat Roadmap Europe: Potentials for large-scale Heat Pumps in District Heating Link

[45] Berlin's largest air-conditioning system is gearing up to generate climate-friendly heat in the future - Vattenfall

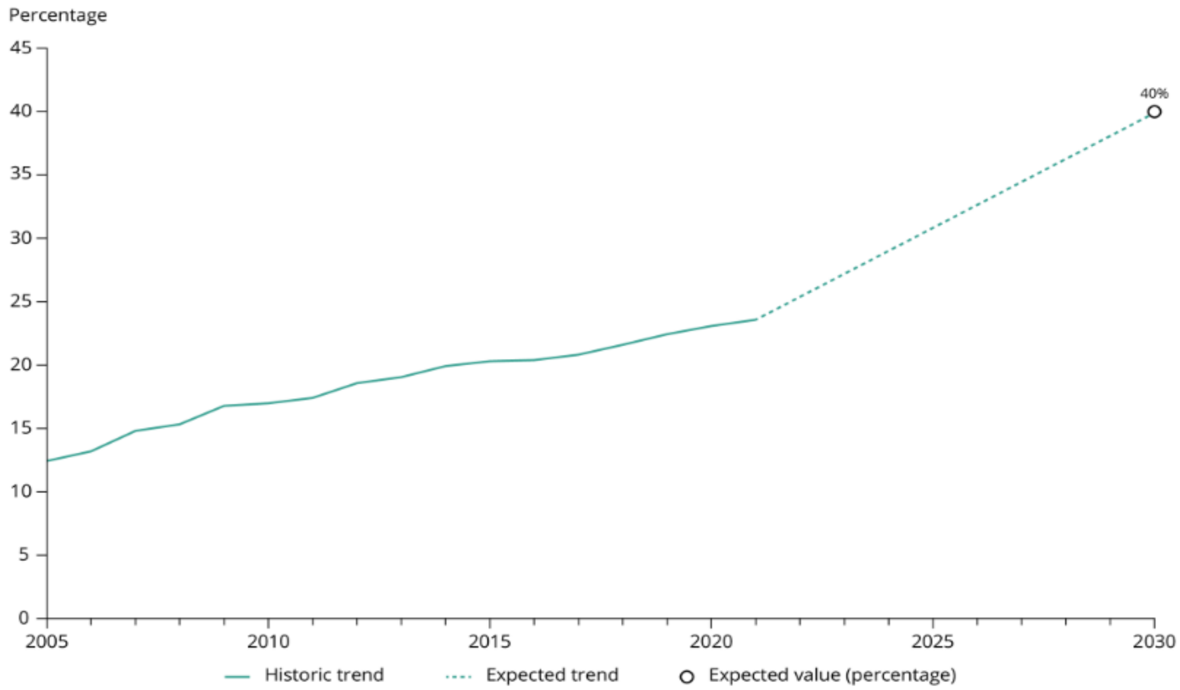
[46] Energy Technologies 2030 COMMUNITY REPORT- Decarbonising Heating WEF_Decarbonising_Heating_2021.pdf (weforum.org)

controls. Additionally incorporating renewable sources (solar thermal, geothermal, biomass fuels and biomethane produced and used in a sustainable way) are essential measures. The intricacies of this transition highlight the need for comprehensive strategies and sustainable practices to achieve a resilient, flexible, and integrated energy system in alignment with ambitious climate targets.

Diverse opportunities and challenges arise from varying energy resources and demand levels among countries. To address this, Member States must evaluate sustainable market potentials, replace fossil-fuel heating systems, and establish clear end-dates for subsidies[22].

As can be seen in Figure 5, **the use of renewable energy sources must increase rapidly** to meet 40% or more of the EU's heating and cooling demand by 2030 and a minimum of 45% across all market sectors. Following the "energy efficiency first" principle can significantly reduce buildings' heating and cooling needs, leading to meeting the EU Renovation Wave target of reducing buildings' energy use by at least 60% by 2030[22].

Figure 5: Historical and targeted shares of renewable energy sources in EU heating and cooling



Source: ESTAT, 2021

Many urban district heating systems are old and inefficient, particularly in central and eastern Europe, with high network losses and a strong fossil-fuel dependence. **Upgrading these systems to reduce their running costs and environmental footprints can be complex and costly**, requiring modernisation of boilers, heat exchangers, heat supply networks, and system controls. Insulating pipes that reduce unintended heat loss better may also be required. Further measures can include densifying and expanding the network, providing new services such as cooling, incorporating new heat networks (including for waste heat), and diversifying to renewable sources that work well in combination. It is remarkable how heat pumps can utilise waste heat sources of low temperatures (below 45°C) in the district heating grid, minimising heat losses. By running when the production of renewable power is high, they can also facilitate the integration of renewable power in electricity networks. District heating could cover up to 50% of the heating demand in Europe, and heat pumps could deliver around 25% of the energy transported by the district heating grid.[47]

The progress made by some EU countries in achieving high shares of renewable sources in final energy consumed for heating and cooling need to be highlighted. **Scandinavian and Baltic countries have achieved more than 50% share by using biomass extensively**, while Portugal has achieved a 42% share by integrating a mix of renewable sources, including heat pumps, solar thermal energy, and solid biomass[48]. It is noted that there are opportunities for all EU countries to use diverse renewable and waste sources for heating and cooling and to capitalise on digitalisation for developing a more flexible, secure, and integrated energy system that encompasses heating, electricity, and mobility networks.

The EU's Renewable Energy Directive favours advanced biofuels over conventional ones, mainly sourced from non-recyclable waste and residues. Bioenergy, produced from agricultural, forestry, and organic waste feedstock, continues to be the main source of renewable energy in the EU, accounting for about 59% of renewable energy consumption in 2021[49]. The EU has committed to moving away from natural gas, towards cleaner options, like biomethane, renewable hydrogen, biogas, and e-gases. **While transitioning from fossil fuels to biomass is crucial for EU energy and climate objectives, it must be managed sustainably** to avoid adverse environmental or biodiversity impacts.

The need to manage biomass sustainably is essential, as a generalised transition from fossil to biomass fuels may exacerbate competition for biomass feedstock. The demand for biomass resources for heating needs to be carefully balanced with the necessity to increase land carbon sinks, in line with the existing legal framework for greenhouse gas emissions and removals from land use, land use change, and forestry. Depending on the environmental impacts of biomass feedstock production and use, solar energy modules and heat pumps can offer more sustainable alternatives for decarbonising residential heating and cooling than the combustion of biomass. Therefore, clean harvesting and land management are crucial for the sustainable use of biomass. This further emphasises the importance of managing biomass resources in a way that respects biodiversity, promotes efficient use, and minimizes harmful effects on the biomass market. The cascading principle and the restrictions in Renewable Energy Directive RED III are integral components of a comprehensive strategy designed to promote the sustainable utilization of biomass.

The cascading principle of biomass use assumes that energy from biomass is produced in a way that minimizes excessive destructive effects on the biomass market and harmful effects on biodiversity. This principle promotes efficient use of bio-based resources through the dissemination of best practices on the cascading use of biomass and support for innovation in the bioeconomy[50]. The guidance on cascading use of woody biomass addresses the circular economy commitment to promote efficient use of bio-based resources. Furthermore, the RED III has proposed introducing a new definition of “primary woody biomass”, to cap its use in the energy mix and electricity and heat production. The revised directive includes the extension of no-go areas for forest biomass to protect in particular primary and old-grown forests, as well as wet- and peatland. It also requires avoiding the use of roots and stumps and to minimise large clear-cuts.

[47] Heat pumps in district heating and cooling systems, IEA, November 17th

[48] ESTAT

[49] European Commission, Directorate-General for Energy Bioenergy report outlines progress being made across the EU Link

[50] European Commission, Directorat General for Internal Market Guidance on cascading use of biomass with selected good practice examples on woody biomass Link

Biomethane is another sustainable alternative to fossil gas. It can be stored and distributed according to demand and plays a crucial role in decarbonising fossil gas heating for homes and industry, as outlined in the EU's biomethane strategy, in the REPowerEU Plan of 18 May 2022, emphasizes the need to scale-up biomethane by 2030. Biomethane, which can be made of organic waste, like manure, food scraps or damaged crops represents a modern way of waste management. By 2024, under the Waste Framework Directive (2008/98/EC), EU countries will be required to collect organic waste separately. This offers an opportunity to scale-up the production of sustainable biomethane and create income opportunities for farmers and foresters[51].

2.4. The investments needed to reach European Green Deal objectives

Achieving climate neutrality by 2050 will be more challenging for some Member States and regions than for others. The economic structures of certain countries heavily reliant on carbon-intensive industries, coupled with diverse energy mixes, geographical conditions, and varying degrees of public acceptance, contribute to the complexity of this goal. Additionally, disparities in financial capacity and infrastructure readiness pose significant challenges, requiring tailored strategies to ensure a fair and effective transition to a low-carbon economy.

For investments in the H&C sector, several EU directives and initiatives play a crucial role in promoting energy efficiency and sustainability. Amongst the most relevant there is the **Energy Efficiency Directive (EED)**, which encourages energy efficiency measures across various sectors, including heating and cooling. Under the EED, Member States have already developed National Energy Efficiency Action Plans setting out actions to reduce demand for heating and cooling; building renovation strategies which provide a better framework for investment; and comprehensive assessments of the potential for high-efficiency cogeneration and district heating. The Commission invited Member States:

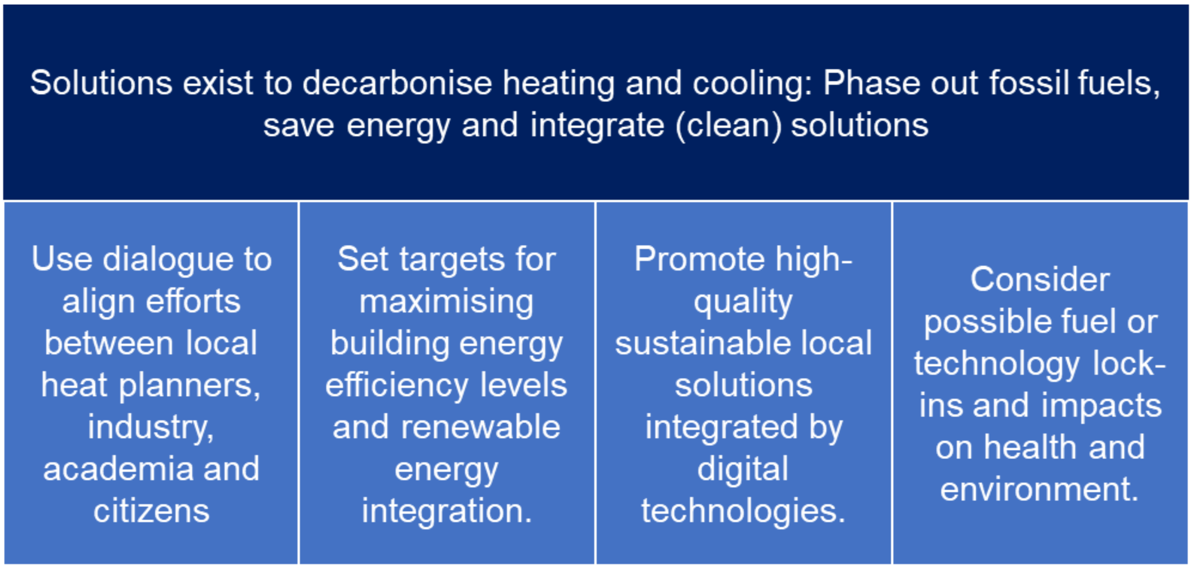
- To review their property laws to address how to share gains from energy improvements in private rented properties between landlords and tenants, and how to share benefits and costs among residents of multi-apartment buildings. This could be set out in the legal status of condominiums or the regulation of building associations;
- To work with stakeholders to raise consumer awareness of household energy efficiency aspects, and especially with bodies, such as consumer associations, that can advise consumers about efficient and sustainable forms of heating, cooling and insulation;
- Promoting renewable energy through a comprehensive approach to speed up the replacement of obsolete fossil fuel boilers with efficient renewable heating and increasing the deployment of renewable energy in district heating and CHP;
- Supporting local authorities in preparing strategies for the promotion of renewable heating and cooling.

To meet the EU's climate change mitigation targets, national decarbonisation strategies for heating and cooling must include significant energy conservation measures and phase out fossil fuels in a timely manner. Figure 6, based on EEA briefing 'Decarbonising heating and cooling — a climate imperative[8], represents a summary of four major solutions proposed to achieve climate neutrality by 2050. In this context, fostering effective dialogue becomes crucial for aligning efforts among local heat planners, industry, academia, and citizens. This collaborative approach is complemented by the establishment of targets, specifically focusing on maximum building energy efficiency and the seamless integration of

[51] European Commission Biomethane - (europa.eu) Link

renewable energy. By setting clear objectives, a robust framework is created to promote sustainable practices. Additionally, the endorsement of high-quality, sustainable local solutions, coupled with the strategic application of digital technologies, serves to enhance the overall efficiency of heating and cooling systems. Furthermore, a holistic transition approach necessitates a careful consideration of potential fuel or technology lock-ins and a thorough assessment of their impacts on health and the environment.

Figure 6: Four major solutions to decarbonise H&C.



Source: Based on EEA briefing Decarbonising heating and cooling — a climate imperative[52]*.*

In the pursuit of climate neutrality, the adaptability of modern district heating and cooling systems becomes evident, particularly in urban environments where localized solutions are crucial. Modern district heating and cooling systems offer a versatile platform for integrating various emissions-neutral energy sources, aligning with the broader goal of sustainable energy practices.

Nevertheless, the decision to invest in such systems necessitates a nuanced evaluation of both advantages and disadvantages. One key consideration lies in the longevity of heating and cooling appliances, which often surpass a decade. A shift from traditional fossil fuel-based boilers to biomass systems, while environmentally beneficial, introduces the potential for a prolonged fuel lock-in[22]. This underscores the importance of a comprehensive assessment, examining implications not only for feedstocks and land carbon sinks but also for public health. Balancing the advantages of emissions reduction with the potential long-term impacts becomes imperative in steering toward a genuinely sustainable and cost-effective transition.

Considering that the H&C sector is a significant contributor to energy consumption and greenhouse gas emissions in the EU, the National Energy and Climate Plans (NECPs) include specific measures and targets aimed at decarbonizing and improving the efficiency of this sector. Some common strategies found in NECPs for the heating and cooling sector include:

- **Increasing Renewable Energy:** Plans often emphasise the use of renewable energy sources for heating and cooling purposes. This includes expanding the deployment of technologies such as solar thermal, geothermal, biomass, and heat pumps to replace traditional fossil fuel-based heating systems.
- **Energy Efficiency Measures:** NECPs frequently outline measures to improve energy efficiency in buildings and industrial processes, which can significantly reduce the

[52] Decarbonising heating and cooling — a climate imperative — European Environment Agency (europa.eu)

energy demand for heating and cooling. This might include promoting better insulation, modernizing heating systems, and encouraging district heating and cooling networks.

- **Electrification:** Some countries focus on electrifying the heating and cooling sector by promoting the use of electric heat pumps and electric boilers. This approach can be particularly effective in regions where electricity is increasingly sourced from renewable energy.
- **District Heating and Cooling:** Many NECPs include plans to expand district heating and cooling systems, which can increase energy efficiency and allow for the integration of renewable energy sources.
- **Support and Funding:** Governments often allocate funding and provide incentives to support the adoption of cleaner heating and cooling technologies and practices.

Significant resources are put by Member States in energy efficiency measures due to its potential to reduce the overall energy demand for heating and cooling. This reduction in energy demand subsequently lessens the required amount of renewable energy sources. Moreover, energy efficiency measures often involve modernizing heating systems, integrating renewable energy technologies, or electrifying the sector. Parallel to energy efficiency, the focus on increasing renewable energy remains indispensable. However, the effectiveness of this strategy can be conditioned by the availability of support and funding, as well as the existing energy infrastructure. It is important to note that the specific details of each country's NECP for the heating and cooling sector can vary significantly based on their unique circumstances, energy mix, and policy priorities. Since NECPs are subject to regular updates and revisions, the most recent information on each country's plans would be available from the European Commission and the respective Member State's government websites.

Table 1 provides an overview on Member States' planned investments in H&C, as well as their target share of renewable energy in the H&C sector by 2030 and their RES share based on NECPs approved in 2019.

Table 1: Member States' investment need and investment gap to achieve 2030 H&C targets.

Country	Investment needs 2030 H&C[53] (in € bn)	2020 RES share in the total energy consumption for H&C (in %)	2030 target RES share in the total energy consumption for H&C (in %)
Austria	40.1	36.5	40.6
Belgium	3.4	8.0	11.3
Bulgaria	19.8	31.3	42.6
Croatia	0.48	33.3	38.0
Cyprus	0.91	31.9	39.4
Czech Republic	1.38	20.7	30.7
Denmark	0.02	54.0	60.0
Estonia	0.35	55.3	63.0
Finland	0.344	54.0	61.0
France	12.25	26.0	38.0
Germany	N/A	16.0	24.2
Greece	N/A	30.6	43.0

[53] These investment needs are derived from Member States' NECPs. Voices considered are "H&C", "RES heat", "CHP and district heating networks", "Individual boiler and heating system modernisation", "H&C phasing out fossil fuels", "Others H&C". Other voices that were not considered as not in the scope of the ID-E but that still represent relevant investment needs for the H&C sector are "energy efficiency", "building renovation", and "NZEB".
Source: https://publications.jrc.ec.europa.eu/repository/handle/JRC124024

Country	Investment needs 2030 H&C[53] (in € bn)	2020 RES share in the total energy consumption for H&C (in %)	2030 target RES share in the total energy consumption for H&C (in %)
Hungary	0.11	18.2	28.7
Ireland	N/A	7.8	24.0
Italy	14	20.9	33.9
Latvia	1.7	53.4	57.6
Lithuania	0.57	50.9	67.2
Luxembourg	0.21	13.7	30.5
Malta	0.3	22.1	25.8
Netherlands	1.85	7.8	13.0
Poland	8.3	17.4	28.4
Portugal	N/A	34.0	38.0
Romania	0.8	25.2	33.0
Slovakia	0.5	10.9	19.0
Slovenia	N/A	36.4	41.4
Spain	92	18.0	31.0
Sweden	20	69.2	72.2

Source: Member States' National Energy and Climate Plans (NECPs) and Recovery and Resilience Facility (RRF)

However, these investments are likely to represent only a part of the actual investments that the H&C sector will receive. This is due to three equally important reasons. First, buildings account for more than two-fifths (42%) of all final energy consumed by all sectors, but most of the investments targeting buildings are included as part of building renovation or energy efficiency interventions, which are outside the scope of the ID-E and, therefore, of this Study. Second, these investment needs are based on the NECPs approved in 2019. They, therefore, pre-date Fit for 55 and REPowerEU increased ambitions and targets. Member States are currently in the process of revising their NECPs, and updated ones are expected to be approved in mid-2024. Third, heat pumps and district heating represent two important technologies for heat production, but they can be considered sustainable only as long as the energy they use comes from renewable sources. Henceforth, the H&C sector will significantly benefit from investments made by Member States in renewable energy production, dealt with in one of the other Studies produced as part of the ID-E[54]. Particularly because of this latter reason, the share of renewable energy used in each country in the H&C sector is of particular importance and interest.

From Table 1, we can conclude that Member States' 2030 targets for RES share in energy consumption for H&C vary significantly. **Nordic and Baltic countries generally have very high targets**, ranging from over 57.6% of Latvia up to 72.2% of Sweden. According to International Energy Agency (IEA), the five Nordic countries (i.e., Denmark, Finland, Iceland, Norway, and Sweden) are in a strong place to lead on goals related to carbon use and climate change, due to factors such as their renewable energy resources, strong economic systems and policies that favour efficiency. As Table 1 demonstrates, Sweden has the highest share of energy from renewable sources (69.2%) with more than half of their energy from renewable sources in its gross final consumption of energy, relying mostly on a mix of biomass, hydro, wind, heat pumps and liquid biofuels. The second highest share had Estonia (55.3%), relying mostly on biomass and wind), then Finland (54%) and Latvia (53.4%) (both using mostly biomass and hydro). According to early estimates from the European Environment Agency

[54] Visit the Investors Dialogue on Energy website to access all published Studies and Reports. https://energy.ec.europa.eu/topics/funding-and-financing/investors-dialogue-energy_en

(EEA), 22.5% of the energy consumed in the EU in 2022 was generated from renewable sources. The share of renewables in Europe is expected to keep growing. **Eastern European countries tend to have more spread targets**, ranging from 19% of Slovakia up to 67.2% of Lithuania. These lower targets should nonetheless not be read as smaller ambitions, but more likely to the fact that these countries' H&C sectors are still heavily reliant on fossil fuels, and thus require more time, effort, and financing to decarbonise. In central and eastern Europe, numerous urban district heating systems face significant challenges, including outdated infrastructure and their poor maintenance. These range from inefficient heat production and network losses to a heavy reliance on fossil fuels. Modernizing these systems for cost-efficiency and sustainability involves complex considerations, including economic and environmental trade-offs. Upgrading may include measures like modernizing boilers, heat exchangers, and heat supply networks, and incorporating smart technologies. Strategies should also involve insulation improvement, network expansion, offering new services, and transitioning to diverse and renewable sources like solar thermal and heat pumps.

Nonetheless, **the two countries with the lowest targets are Belgium and the Netherlands**, with 11.3% and 13%, respectively. Although Belgium reached a 9.9% share[55] of renewable energy sources in 2019, it sets ambition to increase it to 17.5 % share by 2030, focusing mainly on wind and photovoltaic energy, waste heat, and biofuels. In the Netherlands, the share of consumed energy derived from renewable sources has been also increasing over the years- it rose to 15% in 2022[56]. Despite these increases, the Netherlands still remains far behind other countries in the EU. Although the Netherlands has made significant progress in the last years, it is still heavily reliant on fossil fuels. The increase in the share of renewable energy was largely due to rising solar and wind power capacity. To address this challenge, the government is offering incentives to businesses to invest in sustainable energy, aiming to achieve a low-carbon energy supply by 2050 through the promotion of CO_2-low energy forms, including solar energy, onshore and offshore wind energy, biomass energy, geothermal heat, and hydropower.

According to the "Energy Efficiency 2023" report by IEA[57] priority for **countries with higher temperatures** is therefore not necessarily to increase building electrification so much rather to improve cooling efficiency, such as through using passive cooling, efficient building design and high efficiency space cooling equipment. District cooling can also be an efficient solution and is less susceptible to demand peaks.

The RED III (detailed in section 2.2) **mandates binding targets for Member States** with an annual average increase of at least 0.8 percentage points as an annual average between 2021 and 2025, followed by a minimum of 1.1 percentage points between 2026 and 2030. To achieve an overall average increase of 1.8 percentage points at the Union level, additional indicative increases or top-up rates must be calculated specifically for each Member State.

A study from Aalborg University[58] annualized heat sector investment costs in 2015 at € 70 bn/year, with projections to € **100 bn/year in 2050** including €14 bn/year for electricity grids to support increased electric heating through individual and district heating heat pumps. Over the period from 2015 to 2050, there is a notable transition: individual heating is expected to decrease from 82% to 44% of annual costs, while collective systems and district heating infrastructure rise significantly. District heating's share escalates from 12% to 18%, and distribution infrastructure from 5% to 24% by 2050.

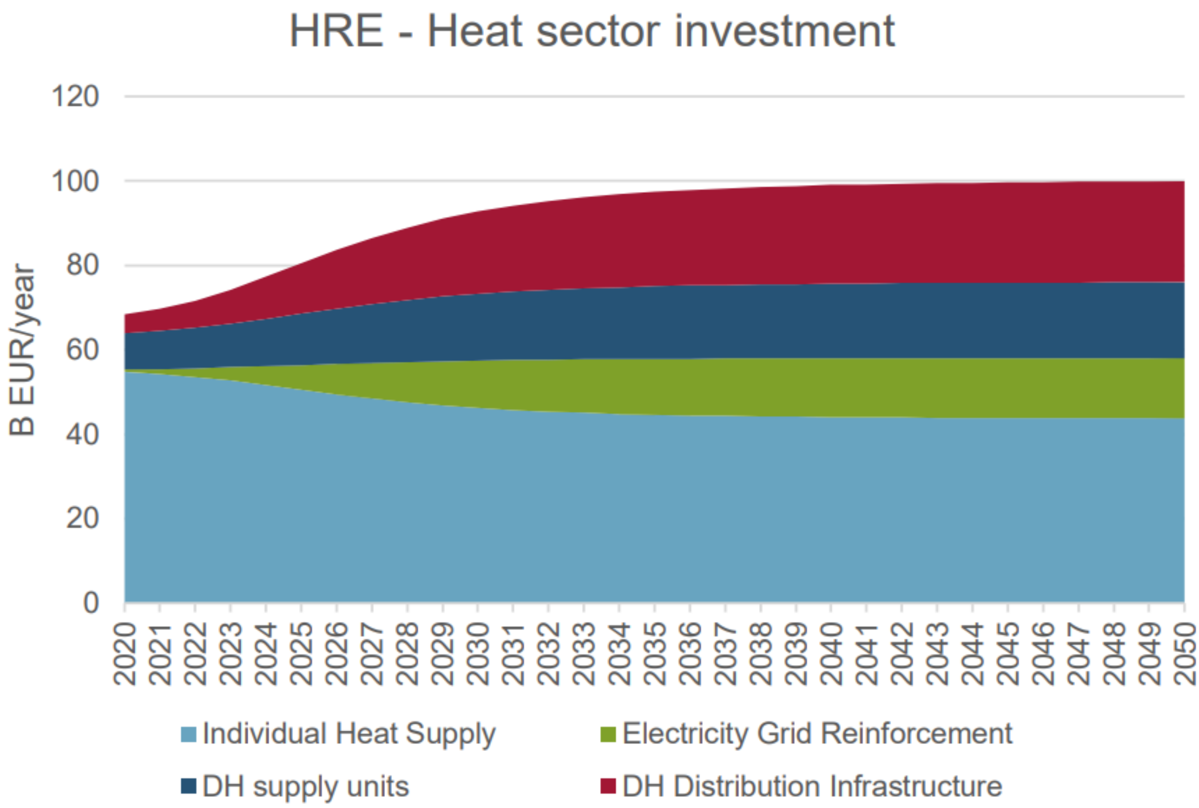
[55] European Parliament Think Thank - Climate action in Belgium: Latest state of play Link

[56] CBS NL Renewable energy share rose to 15 percent in 2022 Link

[57] INTERNATIONAL ENERGY AGENCY (IEA) Energy Efficiency 2023 Link

[58] Neves J. et al Heat Roadmap Europe: Potentials for large-scale Heat Pumps in District Heating, Aalborg University Link

Figure 7. Annualised heat sector investment costs roadmap.



Source: Heat Roadmap Europe (HRE)[59],[60].

2.5. Economics of Heating and Cooling

This section provides an overview of both existing traditional business models and introduces new and innovative ones, along with a guide on revenue and cost management. Following this, it offers examples illustrating the economic implications for various technological solutions ranging from early-stage concepts to commercially mature technologies.

Technological advancements play a crucial role in reshaping the H&C sector. Ongoing progress focuses mostly on technologies such as geothermal systems, solar thermal solutions, heat pumps, combined heat and power (CHP) or smart metering, and more (illustrated in Figure 8). These innovations aim to enhance the efficiency and sustainability of the heating and cooling sector. H&C technologies at different Technology Readiness Levels (TRLs) present a range of economic prospects, from investment potential at various developmental stages to eventual savings in costs and potential disruptions in market dynamics. The final subsection of this chapter addresses varied financing mechanisms necessary for heating and cooling technologies at various TRLs.

Business models, revenue generation and costs

In the H&C sector, revenues are tied to the diverse business models that supply heat and cold to consumers. Beyond traditional HVAC systems, which employ fossil fuels or electricity, innovative technologies like geothermal heat pumps are gaining prominence for their sustainable approach to temperature control. Numerous factors propel revenues in this sector

[59] S. Paardekooper et al., “Quantifying the Impact of Low-carbon Heating and Cooling Roadmaps,” Heat Roadmap Europe, Deliverable 6.4, 2018

[60] Mathiesen, Brian Vad, et al..“Towards a decarbonised heating and cooling sector in Europe: Unlocking the potential of energy efficiency and district energy.” (2019).

such as demand for heating and cooling services, regional energy source availability, technological advancements, and government policies all play pivotal roles. For instance, areas with extreme temperatures often experience heightened demand, driving up revenues.

Business models in supplying heating and cooling solutions

The standard business model of delivering heating and cooling typically involves the manufacture, sale, use, and eventual disposal of equipment. HVAC (Heating, Ventilation, and Air Conditioning) companies often follow this model, as they manufacture and sell heating and cooling equipment. After installation, the customer is responsible for keeping up with the maintenance, repairs, and ongoing operation of the system. The company often offers additional services such as periodic maintenance contracts or emergency repair services for an additional fee and may also provide disposal management services for old equipment. Therefore, customers still rely on the expertise of the company's technicians for installation, troubleshooting, and servicing of their HVAC systems. This model places the ownership and maintenance burden squarely on the customer, who assumes responsibility for ensuring the efficient and effective operation of their heating and cooling equipment throughout its lifespan.

Energy Service Companies (ESCOs) rely work on a different kind of business models. The ESCO business model is based on providing a broad range of energy solutions and services to clients, typically focusing on energy efficiency improvements and energy management. ESCO executes the project and utilizes the income from cost savings or revenues to repay the project costs, including the initial investment.

The conventional ESCO business models are primarily rooted in *Energy Performance Contracting (EPC)* financial mechanism that facilitates the funding of project based on the savings or revenue they generate. The EPC provides the customer with a guaranteed level of energy savings and the ESCO with a reliable source of revenue. ESCO commits to delivering a set of energy efficiency measures to the client, ensuring that the resulting energy bill reductions cover the initial investment over the EPC period. Rigorous measurement and verification methods are essential for validating the anticipated savings. Under the performance guarantee model, the ESCO only receives payment upon successful delivery of the agreed-upon energy or cost savings. Various types of EPCs exist, each intertwined with distinct underlying business models. The four most common ESCO traditional models are[61]:

- **Shared Savings Model**- the ESCO takes on both performance and credit risks during the EPC project. Energy savings are shared between the ESCO and the client based on a predetermined agreement. Upon project completion, ownership of energy-efficient equipment transfers to the client, who then retains all subsequent energy savings.
- **Guaranteed Savings Model**- the ESCO bears performance risk, not credit risk. The client finances the EPC project through banks, investors, or its own resources. The ESCO ensures a specific level of energy savings; if actual savings fall short, the ESCO compensates the client. Conversely, if savings exceed the agreed threshold, the ESCO and client share the excess based on a predetermined ratio.
- **Energy Cost Trust Model (or Chaffee Model)**- the ESCO may offer a complete energy service including both energy supply and energy efficiency. This model involves energy supply contracting, with the ESCO assuming the client's energy supply. The client pays a fee to the ESCO, possibly deducted from the energy bill. If the bill surpasses a set threshold, the ESCO compensates the client for the excess. At the EPC contract's end, the client retains all energy savings.
- **Finance Lease Model**- the ESCO secures financing from a lease company using future energy savings as collateral. The lease company supplies energy efficiency

[61] De Tommasi, L., Papadelis, S., Agrawal, R., & Lyons, P.F. (2022). Analysis of business models for delivering energy efficiency through smart energy services to the European commercial rented sector. *Open Research Europe*.

equipment for the project, retaining ownership throughout. The ESCO's client pays for the equipment with energy savings over an agreed period, ultimately gaining ownership at the project's end.

However, while this traditional model has been prevalent, the heating and cooling industry is evolving with **new business models that focus on sustainability, energy efficiency, and innovative technologies**. This evolution is motivated not only by environmental considerations but also by the increasing demand for effective heating and cooling solutions. **Recently, new business models are emerging mostly to address the hurdle of relevant upfront costs**. The energy efficiency gap inspired the creation of ESCO model, which allows service companies to profit from energy savings.

In a **Servitisation business model,** customers **pay for a service**, i.e., the actual usage or through subscription-based plans. Providers often go beyond conventional offerings by integrating energy optimization services into subscription packages, ensuring peak efficiency in heating and cooling systems. The most common examples are:

- **Heat-as-a-Service (HaaS)** - customers pay based on the units of heat they consume. HaaS supports the deployment and operation of distributed energy resources and demand-side management. It provides energy advice services and manages energy assets[62]. This model provides the service provider with a steady stream of revenue over the contract period. This proactive approach towards environmental stewardship aligns with consumer preferences for eco-friendly practices, potentially justifying higher subscription fees.
- **Cooling-as-s-Service (CaaS)[63]**- customers pay based on the units of cooling they consume. This model strengthens incentives for efficient consumption.
- **Efficiency-as-a-Service (EaaS)[64]-** customers pay fixed-cost-per-unit of the energy efficient service used, such as euros per ton of refrigeration. The development of an enhanced EaaS business model requires the analysis of the potential opportunities for energy efficiency, flexibility, and renewable energy deployment as well as the analysis of energy benefits.
- **Solar-as-a-Service (SaaS)[65]-** customers pay the fixed fee which is determined by the amount of solar energy the customer is expected to use. The payment model is similar to a subscription service, making it predictable for the customer. The provider leases PV panels and is responsible for financing, installation, and maintenance, offering a solar energy tariff and dealing with energy export agreements.

Another category of **new business models is (equipment) leasing**: the customers are allowed to repay the cost of a heat pump, a biomass boiler or another H&C device through a monthly fee. It is either the utility providing the upfront financing or a third company offering subscription services in exchange for the installation, maintenance, and energy use. The examples are:

- **Heat-Pump leasing[66]-** customers pay a regular fee, typically on a monthly basis, to use the heat pump system. The leasing company retains ownership of the equipment, sometimes through a dedicated special purpose vehicle, and is responsible for maintenance, repairs, and replacement as needed.

[62] Irena – International Renewable Energy: Energy as a service: Innovation Landscape Brief Link

[63] Cooling as a Service | CaaS (caas-initiative.org)

[64] About - EaaS - Efficiency as a Service (eaas-initiative.org)

[65] Key provisions in a solar as a service agreement (III) | Circusol

[66] Heat Pump Rental & Leasing | Pure Thermal

- **Geothermal resource leasing[67]-** individuals or companies obtain the rights to explore, develop, and utilize geothermal energy resources and pay for the rights to access them. This typically involves leasing land from the government or private landowners where geothermal reservoirs are located (which is common in western United States, as most of geothermal energy resources are close to the earth's surface).

As the heating and cooling industry continues its shift toward sustainable and efficient practices marked by innovative business models, it is essential to delve as well into the technological foundations propelling this transformation. Box 1 presents three examples of heating and cooling technologies and their associated revenue models, illustrating how these innovations drive not only operational changes but also shape the economic frameworks within the sector.

Box 1: Focus on examples of H&C technologies and their revenue drivers.

Focus on major H&C Technologies and their revenue drivers:

- **Heat Pumps**: a popular technology for providing heating and cooling in both residential and commercial settings. They work by transferring heat from one location to another using electricity. The revenue model for heat pumps often involves the sale of the heat pump equipment itself, installation services, and ongoing maintenance contract, or it can be also a part of HaaS or leasing model. In the residential sector, heat pumps are typically sold directly to homeowners or installed by HVAC contractors. In the case of *geothermal systems*, the utilization of a ground-source heat pump allows for the extraction of stable thermal energy from the Earth's subsurface, providing an energy-efficient and sustainable solution for both heating and cooling applications. In the commercial sector, the revenue model might involve contracts with businesses or property management companies.
- **District Heating and Cooling**: district heating systems supply heat to multiple buildings or customers through a network of underground pipes. These systems are more prevalent in urban areas and often use various heat sources, including geothermal, biomass, waste heat, or combined heat and power (CHP) plants. The revenue model for district heating is anchored in long-term contracts established with a wide-ranging customer base, encompassing various sectors of the economy. This diversified clientele includes residential areas, industrial facilities, commercial enterprises, public buildings, and more. Within this spectrum, district heating providers forge agreements with homeowners, manufacturers, businesses, and government entities, all of whom rely on the consistent supply of heat for their heating and hot water needs. This diverse customer structure is of paramount importance not only for the sustainability of district heating systems but also for the generation of revenues. It provides stability and resilience to these systems, as fluctuations in demand from different sectors may offset each other. Additionally, such diversity offers district heating companies the ability to adapt to changing energy landscapes and market conditions. As a result, these companies can better balance their revenue streams, ensuring the continued affordability and reliability of district heating services for a broad cross-section of society. District heating companies generate revenue from the sale of heat energy and sometimes cooling services if the system also provides district cooling.
- **Variable Refrigerant Flow (VRF) Systems:** VRF is a HVAC technological solution which enables precise control of refrigerant flow to different zones within a building, allowing for simultaneous heating and cooling in different areas enhancing energy

[67] Geothermal Resource Leasing and Geothermal Resources Unit Agreements – Policies - IEA

efficiency and individualized climate control. Revenue is generated through the sale of VRF systems and components as well as installation and maintenance services.

Cost management structure

The costs associated with this sector can be broadly categorized into **four** major categories: **capital costs, energy source costs, operational and maintenance costs, as well as compliance and regulatory costs.** These costs are fundamental components irrespective of the scale or nature of the heating and cooling infrastructure being used and apply to both residential and industrial settings. Each of these cost types plays a significant role in the overall financial performance of businesses in this sector for cost reduction and efficiency improvement.

- **Capital Costs:** cover the initial expenses involved in acquiring, installing, operating, and maintaining heating and cooling systems. In residential settings, this might refer to purchasing HVAC systems or heat pumps, while in industrial settings, it could involve extensive infrastructure development for district heating or cooling systems. Capital costs can also include the expenses related to building or retrofitting structures to accommodate energy-efficient heating and cooling systems. Subcategories of the capital costs include:
    - <u>Technology and Equipment costs</u> involve the acquisition and installation of the primary heating and cooling systems. For heat pumps, these costs include the purchase and installation of the heat pump unit itself, with additional components like ground loops for geothermal heat pumps or air handling units for air-source heat pumps. The choice of technology significantly influences upfront costs. Residential spaces might need smaller heat pumps or air conditioning units, whereas industrial facilities might utilize larger or more complex systems.
    - <u>Decommissioning costs</u> refer to the expenses associated with the retirement or removal of heating and cooling systems at the end of their lifecycle. These costs can include dismantling equipment, disposing of components safely, replacement of the equipment.
    - <u>Infrastructure costs</u> encompass the physical elements required for heating and cooling systems. In district heating, for instance, this includes the construction of an extensive network of pipes connecting a centralized heating plant to various buildings. Additionally, the installation of heat distribution systems, such as radiators or underfloor heating, contributes to infrastructure expenses. Infrastructure costs focus on the components required to support the primary heating and cooling equipment.
    - <u>Financing costs</u>, such as interest payments on loans, leasing fees, or administrative costs are overall capital expenditure.
- **Energy Source Costs:** are associated with the consumption of energy used for heating and cooling purposes. Traditional HVAC systems relying on fossil fuels will incur costs related to oil, natural gas, or coal procurement. Conversely, a geothermal heat pump harnesses the stable temperatures of the earth, resulting in lower ongoing energy costs. Energy costs can vary depending on factors such as market prices, energy efficiency of the equipment, and the availability of renewable energy sources. Residential spaces might typically use smaller HVAC systems or heat pumps, while industrial settings could involve larger-scale systems.
- **Operational and Maintenance Costs:** these include expenses related to the consumption of utilities necessary for operating heating and cooling systems, and regular replacement of consumable items, as well as ongoing expenses associated

with the regular upkeep of heating and cooling systems. In the case of HVAC systems, routine maintenance involves tasks like filter cleaning and refrigerant level checks. For district heating systems, continuous monitoring of the network, maintenance of heat transfer stations, and occasional repairs to the pipeline infrastructure contribute to operational costs. Consistent maintenances are essential for both residential and industrial systems. Subcategories of the Operational and Maintenance costs include:

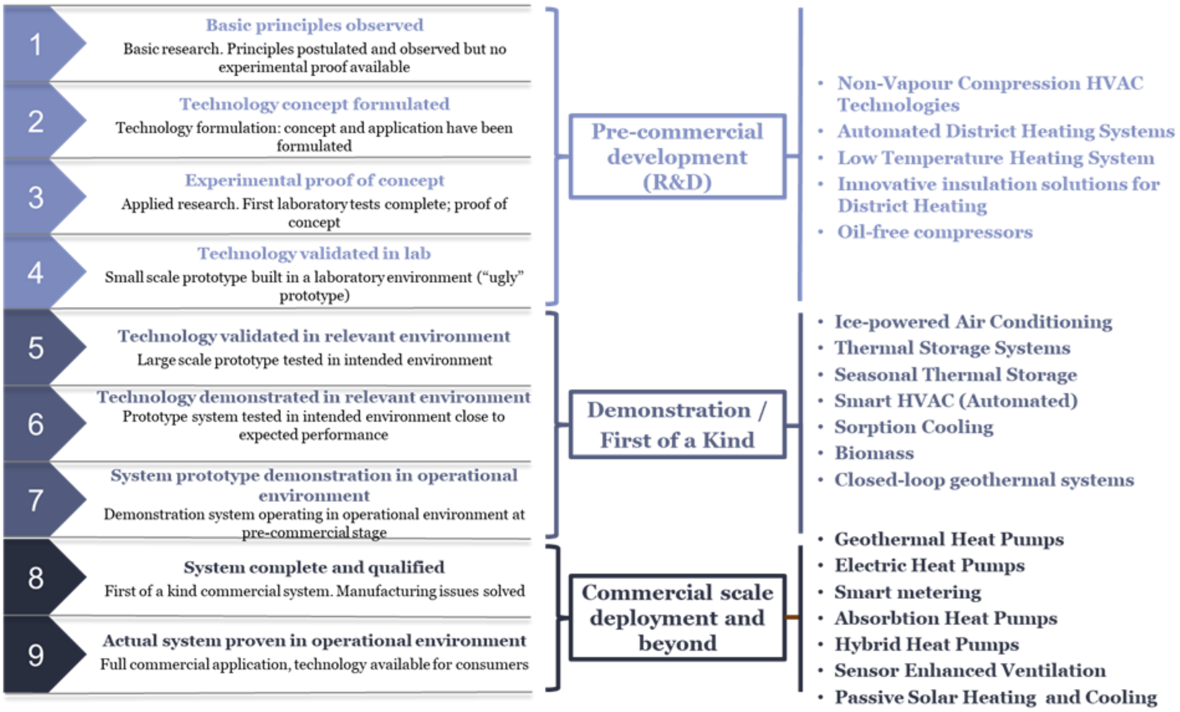
- Labour costs belongs to this category as it is essential for the installation and ongoing maintenance of heating and cooling systems.
- Market and risks management costs cover expenses associated with managing market volatility, supply chain disruptions, and regulatory changes that ensure the continued functionality and stability of the systems. These costs include the implementation of risk mitigation strategies, such as insurances.

- **Compliance and Regulatory Costs:** Ensuring compliance with environmental regulations involves both technological and administrative investments. Compliance with environmental regulations may involve additional costs such as emissions monitoring, carbon pricing, or investments in pollution control technologies. For traditional HVAC systems, this might require the installation of emission control systems. District heating providers may invest in systems that meet air quality standards, contributing to compliance and regulatory costs. Property taxes may fall under this category if they are directly related to adhering to local tax regulations.

Technology Maturity

In the landscape of H&C technologies, the path toward innovation and implementation is marked by various stages of readiness, each representing a crucial milestone in the journey from concept to widespread adoption. For instance, non-vapour compression HVAC technologies still belong to the development phase, as they are not yet widely adopted like traditional vapour compression technologies. In contrast, geothermal heat pumps, passive solar heating, and cooling are already widely adapted into the market. Figure 8 was prepared during one of the discussions on “Barriers to investments in H&C” by WG4 and serves as an illustrative guide, categorizing H&C technologies and sub-technologies into distinct tiers of readiness, spanning from pre-commercial development to commercial-scale deployment and beyond. While this figure does not aim to encompass the entirety of available H&C technologies, it offers valuable insights by presenting examples across Technology Readiness Levels (TRLs) 1 to 9, further grouped into categories such as "pre-commercial development," "demonstration/first of a kind," and "commercial-scale deployment and beyond." This categorization provides a comprehensive overview of the diverse landscape of H&C solutions, highlighting their current stage of development and their potential role in shaping the future of heating and cooling systems.

Figure 8. TRL indicative clustering (from 1- concept till 9- commercial adoption) of energy technologies and examples of the H&C technological solutions with respect to their TRL maturity.



Source: WG 4 Heating & Cooling, Working Group Report on Meeting N.1. Barriers to investments

Technologies ranging from early-stage concepts to commercially mature solutions are spread across a spectrum of TRLs, each presenting unique challenges and opportunities for stakeholders involved in research, development, investment, and deployment. In this context, understanding the economic consequences of technologies at various TRLs is essential for effectively navigating the complexities of the heating and cooling sector.

Regarding the **emerging technologies from TRL 1 to 4** -"pre-commercial development", the major economic implications are:

- Increased Research and Development (R&D) expenditure: early-stage technologies require significant R&D investment to advance from proof of concept to prototype. For example, innovative insulation solutions for district heating systems may require extensive financial support from R&D related projects to develop and test new materials or construction techniques.
- Venture Capital (VC) investments: startups and early-stage companies developing not yet mature technologies often rely on venture capital[68] or angel investment to fund their research and development efforts. Investors in this space understand the higher risk associated with early-stage technologies but may expect significant returns if the technology successfully advances to higher TRLs. In exchange for funding, venture capitalists usually receive equity in the company. An example could be oil-free compressors, which may attract venture capital funding due to their potential to disrupt the traditional HVAC market.

Regarding the **advanced, but not yet mature technologies, that fit into TRL 5 to 7**– "demonstration/first of a kind", primary economic consequences include:

- Government Grants and Incentives: governments may offer grants, subsidies, or tax incentives to support the demonstration and commercialization of TRL 4-7

68 10 Venture Capital Firms Investing in Early-Stage Startups (foundershield.com)

technologies. These incentives help offset the high upfront costs associated with scaling up the technology and can reduce the financial risk associated with investing in innovative technologies, making them more attractive to businesses and investors.

- Market Validation: technologies at TRL 4-7 typically undergo pilot projects or demonstrations to validate their performance and feasibility at larger scale. These projects involve collaboration between technology developers, industry partners, and end-users to test the technology in real-world settings. Successful demonstration projects provide market attracting investment from private equity firms, strategic partners, and utilities. Investors are more likely to commit capital to technologies with proven performance and commercial potential.
- Market Transformation: the advanced H&C technologies can lead to market transformations within the heating and cooling sector. For instance, the growing demand for energy-efficient and environmentally friendly solutions may disrupt traditional HVAC markets dominated by fossil fuel-based systems. This can create opportunities for new market entrants and innovative business models.

Regarding the **mature technologies, that fall into TRL 8 to 9** – “Commercial-scale deployment and beyond”, the major economic consequences include:

- Market Penetration and competition: commercially mature technologies at TRL 8-9 penetrate the market and compete with traditional technological solutions. Companies must differentiate their offerings through innovation, quality, and customer service to gain market share. For example, electric heat pumps compete with traditional HVAC systems based on factors such as energy efficiency, reliability, and upfront costs. Manufacturing commercial-ready technologies requires securing reliable and efficient supply chains for raw materials, components, and equipment. This can stimulate the growth of supplier industries and encourage investments in infrastructure and logistics, further bolstering economic activity.
- Cost Savings: As H&C technologies progress through TRLs, they often become more cost-effective and efficient. This can result in cost savings for both consumers and businesses. For example, more efficient heating and cooling systems can lead to lower energy bills for homeowners and reduced operating expenses for commercial buildings.
- Regulatory Compliance: directly influences economic outcomes by impacting costs, market access, and competitiveness. Meeting industry standards and regulatory requirements ensures market acceptance, customer trust, and long-term viability, shaping economic success in sectors like heating and cooling.

Overall, the progression of H&C technologies across various TRLs offers a spectrum of economic opportunities: from investment potential across different stages of development to eventual cost savings and market transformations. Further advancements in H&C technologies may drive job creation, economic growth, and can contribute to energy security and resilience by reducing dependence on imported fossil fuels.

What type of financing is needed

The type of financing needed to bring to the market different H&C projects is driven by the type of heating and cooling technology (district heating, heat pumps, HVAC, geothermal, solar, biomass, etc.), the financial situation of the operators, and the maturity of technologies. More specifically, the type of financing needed reflects the risk profile associated to a certain point in the technology’s maturity: as technologies pass through each stage of the maturity scale, the level of risk associated with technology performance is reduced; at the same time more mature technologies that are deployed at large scale may face broader risks related to, for example, market access and public acceptance. Moreover, the type of financing also depends on other issues, such as the specificity of technological systems, the financial situation of entities operating in the sector, and the availability of technology.

From emerging proof-of-concepts to commercially viable solutions, technologies progress through different stages of Technology Readiness Levels (TRLs), as presented in the previous section. Understanding the financing needs associated with each TRL is essential for supporting research, development, and deployment efforts in the H&C sector. This section explores the diverse financing mechanisms required for heating and cooling technologies across different TRLs, highlighting the financial strategies necessary to drive innovation, scale up operations, and achieve market success.

H&C technologies situated in the lower TRL spectrum encounter distinct challenges marked by heightened risk and a conspicuous economic viability gap. This category of technologies, often in the nascent stages of development, deals with uncertainties surrounding their commercial feasibility and economic returns. To bridge this commercial viability gap, various forms of public support become instrumental, especially **grants** facilitated by governmental initiatives or EU funding programs like the Innovation Fund and Horizon Europe. Note that, EU financing programmes provide complete coverage across different stages of maturity which is illustrated in Figure 16 in subsection *Maturity stage covered* of chapter 3.1.

Aiming to mitigate the inherent risks and reduce the technology's risk profile, mechanisms such as **loan guarantees, equity financing, and subsidy** schemes play pivotal roles. These instruments not only lower lending requirements but also foster a conducive environment for the growth of innovative companies and startups. The array of financial mechanisms in the heating and cooling sector is relevant to both residential and industrial domains.

In the Investors Dialogue working group report on Heating and Cooling "*Availability of financial instruments for heating and cooling*" various forms of support are proposed to address financial challenges of public and private sectors[69]. The most important ones are **public funding and grants for CAPEX reduction, risk mitigation and tax incentives.** Experts from the Heating and Cooling working group of the Investors Dialogue agreed that public support in the form of grants or loans is vital in reducing capital expenditure requirements and mitigating technology risks, especially during the research and development phase. A government grant program can for example support the development of an innovative solar thermal heating system, reducing the CAPEX burden on the technology and adopting a tax incentive policy to encourage the adoption of renewable heating systems.

The financing instruments that could be obtained for **emerging technologies from TRL 1 to 4** -"pre-commercial development" includes:

- **Research Grants:** early-stage research and development projects often rely on seed funding from government grants, research institutions, or private foundations to support initial concept exploration. They are typically fundamental research grants provided to researchers to carry out specific research proposals. These grants cover expenses related to materials, equipment, and personnel needed to explore new concepts and conduct feasibility studies. For example, EU funding programme EIC Pathfinder supports early-stage high-risk/ high gain and interdisciplinary cutting-edge technologies.
- **Early-stage investment**: might be provided by angel investors or venture capitalists for promising early-stage startups or entrepreneurs with innovative ideas for heating and cooling technologies. This funding helps validate concepts and move projects closer to prototype development.
- **Seed funding from startup incubators and accelerators:** offer mentoring, networking, provide access to resources, mentorship from industry experts, and

[69] Working group 4 Heating and Cooling, Report nº4; *Availability of financial instruments for heating and cooling*.

potential investment opportunities to help startups accelerate their development, such as seed funding to startups in exchange for equity.

- **Crowdfunding:** Crowdfunding platforms allow entrepreneurs and startups to raise capital from a large number of individuals interested in supporting innovative projects. Crowdfunding campaigns can be used to fund product development, prototype testing, and initial production runs for emerging H&C technologies.

For more advanced technologies with TRL 5-7 the investment for transitioning from prototype to fully functional technology may be obtained from applied research or development national or international grants. For example, grant funding for energy systems like district heating, often originates from higher levels of government rather than the local municipality. This funding reflects the broader national and international importance of such systems and aligns with the overarching goals of sustainable energy use. This external funding serves as a critical financial component for projects related to advanced energy technologies. This holds particularly true for technologies where the aim is to reduce investment costs and enhance the competitiveness of consumer prices. Active municipal involvement in the business model, whether through equity or debt provision, allows local governments to maximize the impact of their project funds. It is worth emphasizing that local authorities play a pivotal role in facilitating individual projects to secure funding from national or international grants.

The financing for **advanced, but not commercially mature yet technologies,** that fall within **TRL 5 to 7** – "demonstration/first of a kind" may be sourced from[70]:

- **Transition Grants:** government agencies may offer specific types of grants supporting the transitions between TRL stages, for example from proof-of-principle to development of validated prototypes. For instance, EU funding programme **EIC Transition grants**[71] supports technology that is demonstrated to be effective for its intended application (TRL 5/6) with a business case and (business) model towards the innovation's future commercialisation. Another example **EIC Accelerator** which supports start-ups and SMEs to scale-up and commercialise breakthrough technologies (TRL 5/6-9).
- **Revolving funds:** unlike traditional grant-based funding, where funds are allocated on a one-time basis and may not be replenished, revolving funds are structured to recycle or "revolve" capital over time. This structure supports specific district energy starter schemes, showcasing the feasibility of major heat networks and catalysing cost reductions and local supply chain development. The repaid capital can then be redeployed in other projects, ensuring a continuous cycle of support for sustainable initiatives. One of the prominent examples can be **Energy Efficiency Revolving Fund (EERF)**[72] designed to stimulate investment in energy efficiency projects by increasing the availability of debt financing for these projects while minimizing the borrowing costs to project developers.
- **Subsidies**: designed to reduce the cost of specific goods, services, or activities for consumers or producers. Subsidies may be directed towards supporting demonstration projects, pilot initiatives, or early commercialization efforts for medium TRL technologies. Subsides can be provided by governments or organizations to incentivize the adoption of specific technologies that align with policy objectives, such as promoting renewable energy or reducing greenhouse gas emissions, and may take the form of direct payments, tax breaks, reduced fees, or other financial incentives.
- **Tax deductions:** are a financial incentive provided by governments to support companies investing in the development and commercialization of innovative

[70] The powerful role financial incentives can play in a transformation | McKinsey

[71] EIC Transition - European Commission (europa.eu)

[72] Energy Efficiency Revolving Fund (EERF) – Policies - IEA

technologies. These deductions allow companies to reduce their taxable income by deducting eligible expenses associated with technology development, scaling up operations, and entering the market.

- **Debt provision**: involves providing loans or debt instruments to support projects related to the development, deployment, or improvement of heating and cooling technologies and infrastructure. Debt provision is often suitable for more mature technologies at TRL 5-9, where there is a demonstrated level of development, market potential, and commercial viability with lower perceived risks and higher certainty of returns on investment for lenders.
- **Loan Guarantees:** provide a form of assurance to lenders, typically banks, governments or financial institutions, as the guarantor (often a government agency or other entity) will cover a portion of the losses. Loan guarantees can be particularly valuable for companies with innovative technologies at medium TRL levels, as they may face challenges in securing traditional loans.
- **Public Guarantees**: aim to lower investment risks for projects involving high-risk technologies. Public guarantees are particularly relevant for advanced technologies, where projects are transitioning from demonstration to commercial deployment. Public guarantees help attract investors by mitigating risks associated with technology performance, market acceptance, and financial viability during the early stages of deployment. Public guarantees and partial risk coverage schemes are most relevant for supporting projects at medium advanced to mature TRLs (TRL 5-9). Public guarantees, such as **first-loss or partial risk coverage schemes**, play a pivotal role in lowering the risk profile of investments. Both contribute to lowering the investment risk for high-risk technologies. Guarantee programs make it more attractive to fund innovations like advanced solar cooling systems, while partial risk coverage schemes provide assurance to investors involved in projects like geothermal heat pumps. A partial risk coverage scheme might ensure for example that a geothermal heat pump project has reduced lending requirements, making it more attractive to investors.
- **Equity Financing**: involves selling shares of ownership to investors in exchange for capital. It’s often used by startups and early-stage companies with high growth potential but limited assets or revenue. Equity financing can also involve strategic partnerships with investors who provide not only funding but also industry expertise, networking opportunities, and mentorship to support the company's growth and development. Equity financing includes venture capital firms, angel investment, private equity investors, crowdfunding, and other forms of equity investment. Equity financing carries risks for both the company and the investors, with potential for high returns if the company succeeds but also the risk of losing the investment if the company fails.
- **Corporate Partnerships**: partnering with a larger corporation can provide access to resources, industry expertise, and additional capital. Corporations may provide funding, expertise, or access to their existing customer base and distribution networks to support pilot projects, demonstrations.

Mature technologies with established revenue streams find themselves in a more bankable position, accessing market-based financing through avenues like **public equity, credit and debt markets, balance sheet financing, and project financing.** WG members noted that one of the constraints of the H&C sector is for projects to reach financial sustainability and bankability without the use of fossil fuel in the mix.

In the case of commercially **mature technologies, that fit into TRL 8 to 9**– “Commercial-scale deployment and beyond”, financing support may include:

- **Project Financing:** structured financing method used to fund specific projects, such as the construction and deployment of large-scale infrastructure or capital-intensive assets. Involves raising capital from various sources, including equity investors, lenders, and other financial institutions, to fund the development and construction of heating and cooling projects. This capital is typically structured to cover the upfront costs associated with equipment procurement, construction, installation, and commissioning. This funding structure spreads financial risk among project stakeholders and aligns repayment with project cash flows. Project financing typically involves long-term debt financing arrangements with tenures aligned with the project's lifespan, which can last over several years or even decades. These long-term financing structures provide stability and predictability for project investors. An important example of energy project financing is **Power Purchase Agreement (PPA)[73]** typically used for larger project applications, that involves a contractual agreement between a developer, investor, and a host customer. PPAs are transformative instruments for the energy transition as they provide renewable project developers with access to finance to deploy new renewable energy sources, while the other party gains access to a stable renewable electricity supply at a predictable price[74].

- **Private Equity Financing:** commercially mature technologies often attract investment from private equity firms seeking to capitalize on proven market demand and revenue potential. Private equity investors often bring not only financial resources but also industry expertise, managerial guidance, and access to extensive networks, which can be invaluable for scaling up operations and accelerating market penetration.

- **Subsidy Schemes (Feed-in Tariffs or Contracts for Difference):** these subsidy schemes are designed to boost future revenue and mitigate market risks for renewable energy projects, including mature technologies. Feed-in Tariffs[75] (FIT) and Contracts for Difference (CFD)[76] provide long-term revenue certainty and price stability for renewable energy producers, making investments in technologies like geothermal heat pumps more attractive to investors. These schemes are typically deployed when technologies have reached commercial maturity and are ready for large-scale deployment. For example, Feed-in Tariff guarantees a steady income for a large-scale solar cooling project, encouraging its adoption and mitigating market risks.

- **Bond financing:** is a type of debt financing where an investor lends money to a borrower, typically a corporate or governmental entity. The borrower issues a bond that includes the details of the loan and its payments. The bond represents a fixed-income instrument, and the investor is essentially buying the borrower’s debt. The borrower agrees to pay the investor a fixed interest rate over a specified period of time and to return the principal amount on the bond’s maturity date. Bonds are frequently used for large-scale financing needs that may exceed the capacity of a single bank or financial institution to provide. Bonds typically have longer maturities compared to other forms of financing, making them well-suited for projects with longer development and payback periods, which are associated with higher TRL technologies. **Green bonds[77]** are a specific subset of bond financing specifically used to fund environmentally friendly projects such as renewable energy projects, energy efficiency initiatives. Through the issuance of green bonds, corporations can raise capital dedicated to supporting heating and cooling projects that prioritize environmental goals. Similarly, financial institutions contribute to this effort by providing sustainable financing options, creating avenues for investments with a focus on eco-friendly solutions. Green bonds are generally associated with larger sustainable projects in renewable energy, infrastructure, or commercial ventures rather than individual residential heating and cooling upgrades.

[73] Long-term Power Purchase Agreements (PPAs) for renewable energy projects – Policies - IEA

[74] eurelectric.org/in-detail/ppas

[75] Renewable Energy Feed-in tariffs – Policies - IEA

[76] Contract for Difference (CfD) – Policies - IEA

[77] Green Bond – Policies - IEA

All of mentioned above financial mechanisms open doors for funding various heating and cooling endeavours, particularly those aimed at enhancing energy efficiency. The funding strategies for H&C technologies must adapt to the diverse financial landscapes encountered at various stages of maturity along the Technology Readiness Level scale. For instance, emerging and protype-based technologies can benefit significantly from a combination of various financial support including grants, loans and equities (private investors, venture capitals, etc). As H&C technologies advance from initial development stages to their commercialization, the strategic utilization of financial support mechanisms becomes essential, since these financial mechanisms play a crucial role in closing economic viability gaps and promoting the shift towards sustainable and efficient H&C solutions.

2.6. Barriers to investment

Transitioning to a more sustainable heating and cooling sector is not without challenges. This chapter provides an overview of barriers affecting heating and cooling projects and investments. For the purpose of this study, a literature review was carried out to identify a long list of barriers to energy production investments from different reliable sources (e.g., EIB, European Commission, IEA, etc.). The identified barriers were grouped into four categories, namely:

- **Policy, Regulatory and Social barriers,** associated with risks and barriers concerning compliance with the regulatory and policy frameworks, the permitting framework, **as well as social acceptance** of these projects on behalf of the general population.
- **Economic barriers,** associated with risks and deriving from economic factors like market dynamics and organization, access to capital, transaction costs, off-taker risks and incentive schemes.
- **Energy market development barriers,** emerging from the immature nature of the market for emerging technologies and business models. They are very interconnected to the economic barriers.
- **Technical barriers,** associated with risks arising from technical features of projects like technology and resource availability, including supply chain risks.

Within each category, some specific barriers were identified, and are summarized in the Table 2. In the following subsections, the WG's insights for each category are shared. All of the barriers and insights are generally applicable to both the residential and the industrial markets, even though each of them may have its specificities.

Table 2. List of barriers to investment in H&C sector.

Risk Group	Specific Barrier	Description
Policy / Regulatory / Social	**Regulation & policy risk**	*Changes in legal or regulatory policies that have significant adverse impacts on project development or implementation (e.g., retrospective changes in support regimes: regulatory lock-in, where renewable H&C solutions are disadvantaged compared to fossil H&C solutions).*
	Lack of commonly accepted standards	*Lack of standards aimed at expanding the available market and counteracting market fragmentation (e.g., for heat pumps or district heating).*

Risk Group	Specific Barrier	Description
	Compliance with EU State Aid & other competition regulation	*Issues arising from compliance of RES-integrated heating and cooling projects with the EU rules that prevent government support actions which may have distortive effects on the internal market.*
	Social acceptance & citizen engagement	*Resistance to the implementation of deep renovation projects in residential buildings (e.g., split incentives between tenant and owner).*
	Lack of information / awareness	*Lack of citizens' awareness of the benefits of new/more efficient heating and cooling systems leading to insufficient interest in investing in replacements of old systems.*
	Administrative requirements (permitting)	*Risk of delays, increased costs and / or project failure generated by the necessity to comply with administrative requirements and acquisition of the necessary permits for implementing and operating the project (e.g., environmental permits).*
Economic	**Market risk**	*Risk deriving from energy price fluctuations on the input side (increase in the price of inputs) and/or that more efficient networks reduce the revenues for energy utilities (because less kwH are sold).*
	Counterparty / Offtaker risk	*Risk that the counterparty in a financial transaction may default on its obligations or stop paying.*
	Availability of finance & access to finance	*A form of market failure whereby financial flows are limited by the fact that capital markets are not used to making certain types of investment and accurately pricing risk.*
	Liquidity risk / Long payback periods	*Operational liquidity issues caused by revenue shortfalls or mismatches between the timing of cash receipts and payments.*
	High upfront costs	*Barriers arising from excessively high levels of CAPEX requirements that characterise heating and cooling projects at the beginning of their life cycles.*
	Unduly high borrowing costs or cost of capital	*Barriers arising from excessively high interest rate that project sponsors face on their debt financing.*
	Small size of projects and high transaction costs	*Refers to the fact that transaction and due diligence costs tend to be similar for all project sizes, driven by administrative procedures, the 'over-the-counter' nature of contractual documentation, and low degrees of standardisation in contracting.*
Energy market development	**Scarcity of investment ready projects**	*Related to the shortage of investment-ready or bankable projects with an attractive value proposition faced by financiers willing to invest in the sector.*
	Inadequate or underdeveloped supply chain & industrialisation	*Refers to disruptions in the supply of components or raw materials that can hinder investments in heating and cooling.*
	Inadequate supply of labour	*Refers to the novel nature of emerging heating and cooling technologies, which will require major upskilling and reskilling.*
	Weak planning and preparation capacities	*Associated with public authorities' limited or insufficient capacity for defining clear and transparent planning strategies concerning the implementation of heating and cooling investments and supply-demand matching.*
Technical	**Technology risk**	*Associated with performance uncertainty of nascent technology or inexperienced and unskilled labour deploying it.*
	Resource risk	*Associated with uncertainties around the availability, future price and/or supply of the renewable energy resource.*

Risk Group	Specific Barrier	Description
	Networks, distribution, and infrastructure risk	*Refers to limits on networks and distribution infrastructures and pipeline for heating and cooling projects.*

Source: Working group report N.1 barriers to investments

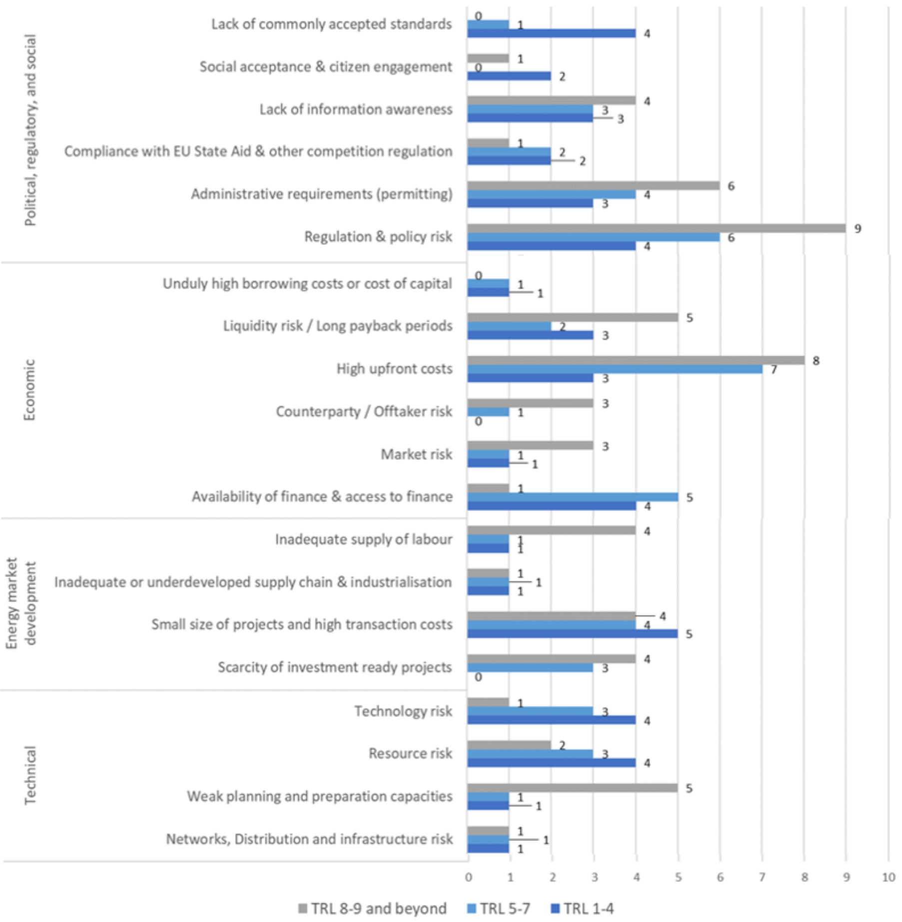
Following this classification, the **Technology Readiness Level (TRL) framework** was proposed as an instrument to rate the acuteness of barriers in function of the maturity of production technologies. After detailed desk research, **WG4 members were invited to identify the most acute barriers.** The discussion[78] was aimed at identifying in particular those barriers that can be effectively and efficiently addressed through financial instruments. More specifically, the discussion focused on the characteristics and causes of barriers to investments in different EU Member States, and at the features of existing financial instruments that successfully tackled one or more barriers. The **WG4 members** discussion was also completed by an online survey that collected in total 12 responses. WG members were asked to select the five most relevant barriers for each of the three main types for heating and cooling technologies.

According to the survey, the two primary barriers for technological solutions within existing TRLs 8-9 and beyond, as well as for medium TRLs 5-7 are “regulation and policy risk”, and “high upfront cost”. Moreover, other significant barriers for these highest TRLs solutions include administrative requirements such as permits, economic challenges related to “liquidity risk/long payback periods”, and “weak planning and preparation capacities” in terms of technical hindrances. On the contrary, the primary barriers for the lowest TRLs 1-4 are evenly distributed across all four sectors, including the previously mentioned regulation and policy risk”, as well as the “lack of commonly accepted standards”, in relation to political, regulatory and social barriers. The major economic barrier concerns the “availability of finance and access to finance”, while the technical barrier involves technological and resource risks. Another challenge for these low TRL solutions lies in developing small-sized projects that generate high transaction costs. Figure 9 provides an overview of the barriers identified as most acute, or most relevant, for H&C investments based on their TRL. In the subsections that follow, we provide more detailed information about participant’s views of the barriers, as well as several examples of the effect of barriers on H&C.

Next subsection of this chapter will present the summaries of the discussion of WG4 members regarding each barrier category.

[78] European Commission, *Investors dialogue on energy. WG4 Heating and Cooling – Working group report N.1 barriers to investments*, September 2022. (Link)

Figure 9 Various levels of importance of barriers to investment in H&C concerning their TRL[79].



Source: WG members' responses to the survey.

Policy, Regulatory and Social Barriers

Regulation & policy barriers derive from changes in legal or regulatory policies that have significant adverse impacts on project development or implementation (e.g., incentive programs, interconnection regulations, permitting process). As evidenced by the EIB, barriers to investments concerning regulation originate from two main issues[80]:

- **Regulatory uncertainty.** The certainty and predictability of the regulatory framework is essential for investments such as renewable energy production projects, which are characterized by high upfront fixed costs. In these contexts, regulation has an important role in determining the costs and benefits of investing through the implementation of incentive and support schemes as well as establishing minimum standards for renewable energy sources (RES) usage and energy efficiency. Unbalanced and unstable regulatory frameworks can compromise investor confidence

---

[79] Please note that the long list of barriers also included:
- **Energy market development:** inadequate or underdeveloped supply chain and industrialization, small size of projects and high transaction costs.
- **Technical:** resource risk, weak planning and preparation capacities.
- **Economic:** counterparty/off taker risk, high upfront costs, unduly high borrowing costs or costs of capital
- **Legal and social:** compliance with EU State Aid and other competition regulation

[80] Breaking Down Investment Barriers at Ground Level - Case studies and other evidence related to investment barriers under the third pillar of the Investment Plan for Europe, *European Investment Bank*, *European Investment Fund*, 2016.

in the credibility of those frameworks leading them to deciding not to invest or to redirect investments to other geographies.

- **Regulatory fragmentation.** Regulatory fragmentation refers to situations where different levels of government of one country (local, regional and national) are not harmonized in terms of regulation and policy. The issue can also arise from differences between regulations of different countries or EU Member States, hampering the development of renewable cross-border projects, which play an important role in the promotion of an integrated energy market at the EU level[81].

One of the major policy risks is related to changes in legal or regulatory policies, such as retrospective alterations in support regimes, as it can detrimentally affect project development or implementation, potentially resulting in regulatory lock-in that disadvantages renewable heating and cooling solutions compared to fossil fuel alternatives. Changes in policies could affect incentives for homeowners to adopt renewable heating and cooling systems, impacting their affordability and attractiveness. Similarly, regulatory shifts might alter support mechanisms or subsidies for large-scale industrial heating systems, influencing investment decisions and operational costs. For example, permitting procedures related to land use (solar heating and cooling) and drilling rights (geothermal heat) are sometimes inefficient and need streamlining.

WG participants identified barriers of political, regulatory (incl. regulatory lock-in), and social nature as the most relevant for investment in heating and cooling. Regulatory barriers were identified by WG members as affecting particularly mature solutions, i.e., those that are ready to be commercialised and need to access financing opportunities to be deployed at scale. WG members largely agreed that frequent changes in regulatory frameworks have resulted in **a lack of long-term visibility of revenues,** creating a non-favourable environment for investors. Some participants pointed out that the current regulatory framework in the EU seems to have set further barriers to investment. For instance, there is an implicit penalty in the replacement of gas heating with electric heat pumps, as electricity, even when produced by renewable sources, is still subject to the "carbon tax" applied to energy generation under the ETS. This sometimes leads to regulatory requirements misaligned with decarbonisation targets. Another example raised was the case of Slovenia, where the prices of various heating energy products have fluctuated within a period of a few years due to regulatory and legislative changes. First wood, then gas, then oil - the instability of prices of these heating fuels represents a barrier to long-term planning and disincentivises households, as well as forces companies to invest in new units, as their energy source might become more expensive in the near future. Other more specific technical aspects, such as the methodology to define the Primary Energy Factor[82] for electricity in the EU energy efficiency and labelling legislation, are also hindering the adoption of electrical solutions, penalising electric heat pump vis-à-vis fossil fuel-driven alternatives.

In the residential market, additional obstacles for household investment were found in the regulatory requirements that differed for existing and new buildings. With respect to

---

[81] With Commission Delegated Regulation 2022/2202 (link), the Commission has adopted the first list of selected cross-border projects in the field of renewable energy (RES). The list comprises three projects, involving a total of seven Member States, namely:

- A hybrid offshore wind park between Estonia and Latvia
- Cross-border district heating grid based on RES between Germany and Poland
- A project to produce renewable electricity in Italy, Spain and Germany for conversion, transport and use of green hydrogen in the Netherlands and Germany.

Although few in number, such projects are an important step towards the creation of an integrated European energy market designed to promote cross-border cooperation between Member States (and between Member States and non-EU countries) in the field of planning, development and cost-effective exploitation of renewable energy sources. In addition, cross-border RES projects may facilitate RES integration through energy storage or hydrogen production facilities, among others, with the aim of contributing to the EU's long-term decarbonisation strategy. More information about the project can be consulted at the following Link

[82] The Primary Energy Factor (PEF) converts final energy to primary energy. It indicates how much primary energy is used to generate a unit of electricity or a unit of useable thermal energy.

energy efficiency and performance levels, the past regulations put high standard requirements on new and renovated buildings. However, this example of the barrier will be overcome by recent key legislative framework - Energy Performance of Buildings Directive (EPBD) established by the EU to boost the energy performance of all the existing and new buildings. **Under the recast of the EPBD, each Member State will adopt its own national trajectory to reduce the average primary energy use of residential buildings by 16% by 2030 and 20-22% by 2035**[83]. For existing buildings, member states agreed to introduce minimum energy performance standards that would correspond to the maximum amount of primary energy that buildings can use per m^2 annually. The purpose is to trigger renovations and lead to a gradual phase-out of the worst-performing buildings and a continuous improvement of the national building stock. For existing non-residential buildings, member states agreed to set maximum energy performance thresholds, based on primary energy use. A first threshold would draw a line below the primary energy use of 15% of the worst-performing non-residential buildings in a member state. A second threshold would be set below 25%. For existing residential buildings, member states have agreed to set minimum energy performance standards based on a national trajectory in line with the progressive renovation of their building stock into a zero-emission building stock by 2050[84].

WG4 agreed that social acceptance and citizen engagement play crucial roles in determining the success and implementation of energy solutions. For example, resistance to renovations due to conflicting interests between tenants and owners might stall residential energy efficiency projects. Similarly, community engagement might influence the acceptance and smooth implementation of large industrial heating and cooling projects within local communities, affecting project timelines and costs.

Furthermore, WG4 participants noted that some key **social barriers** are present at residential level, as **split incentives between housing cooperatives and households resulting in a lack of interest in investing in more efficient heating and cooling systems**. Households naturally seek more stable energy supplies, but there is no observable trend of households switching towards new/more efficient systems. Simultaneously, cooperatives are not interested in investing, as they pass any additional costs on to the households, and hence would not benefit from energy savings or more efficient and renewable H&C systems. The same applies to owners and tenants, with the former not interested in investing in better and renewable H&C solutions as they do not bear the cost of the bills, and the latter less incentivised in investing in such H&C solutions as they do not own the property. This is a particularly relevant barrier for lower-income households. The setting up of clear and ambitious deep renovation schedules with explicit targets for adoption of decarbonised and more efficient heating solutions would be necessary to circumvent all the previous barriers.

One of the barriers related to social acceptance & citizen engagement are illustrated by **the Dutch example of gas-free cooking** and **Finnish public resistance for District Heating and Cooling project**.

[83] Revision of the Energy Performance of Buildings Directive: Fit for 55 package | Think Tank | European Parliament (europa.eu)

[84] 'Fit for 55': Council agrees on stricter rules for energy performance of buildings - Consilium (europa.eu)

Box 2: Examples of social acceptance & citizen engagement cases.

Dutch example of gas-free cooking

The Netherlands, a country with a heavy reliance on natural gas, particularly for heating, faced a transformative shift prompted by fracking-induced earthquakes and public concerns about the environmental and social impacts of natural gas extraction and use, triggering the transformative shift towards becoming entirely gas-free by 2050. The Dutch government emphasized citizen engagement in the transition that were voicing their opinions and concerns, and to be part of the decision-making process during the public debates. A notable initiative involved promoting gas-free cooking[85], making the energy transition relatable to homeowners. Additionally, the government mandated new homes to be almost energy-neutral, and incentive schemes were introduced to enhance energy efficiency in the rental sector. These measures highlight the dual nature of the decarbonization challenge in heating and cooling systems, requiring not only technological solutions but also societal acceptance and citizen-engaging initiatives.

Finnish public resistance for District Heating and Cooling project

In Finland, the expansion of a District Heating and Cooling (DHC) project in the city of Espoo has encountered strong public resistance. Despite aiming to cater to the heating and cooling needs of an expanding urban zone, the project has encountered pushback from both residents and environmental organizations. One of the primary concerns raised by the community was the close proximity of the proposed DHC infrastructure to residential neighbourhoods. Residents worried that the project's expansion might disrupt their daily lives, causing noise pollution, and affecting property values. They argued that the construction and operation of DHC facilities might lead to inconveniences and potential health impacts. Moreover, environmentalists have voiced concerns about the potential impact on local flora and fauna due to the expansion of the DHC network. They argued that the development could disturb natural habitats and wildlife corridors in the surrounding areas. The opposition to the DHC project has resulted in several public protests, community meetings, and petitions against its implementation. Environmental groups have also raised legal objections, citing potential violations of environmental regulations and inadequate assessments of the project's ecological impact. In response to the public resistance, the local government and project developers have been engaging in dialogues with community representatives to address their concerns and explore potential alternatives. However, finding a balance between meeting the city's growing heating and cooling demands and addressing public and environmental concerns has proven challenging.

The case in Espoo highlights the importance of considering public acceptance and environmental impacts when planning and expanding District Heating and Cooling projects. As the demand for sustainable energy solutions increases, finding common ground between local communities, environmental interests, and urban development goals becomes essential for the successful implementation of such projects.

WG4 participants also agreed that an **important social barrier is related to lack of awareness of the benefits and value of investments** in more efficiency and better-performing heating and cooling solutions, **coupled with burdensome administrative procedures**. It involves challenges related to the lack of easily accessible information on pricing and existing system performance, which hinders consumers' ability to compare solutions and leads to continued use of less efficient technologies. Since beneficiaries do not

[85] Rapid Transition Alliance- The dash away from gas: how the Netherlands kicked a big fossil fuel habit Link

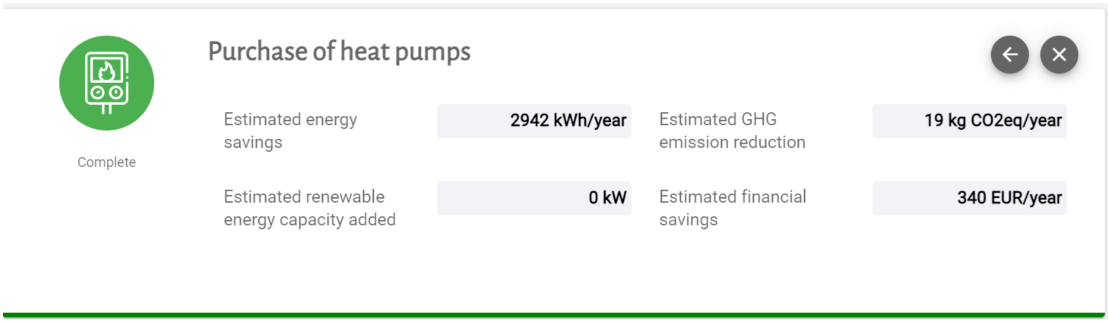
have a clear overview of the advantages that such intervention could bring them, they do not invest even if public authorities offer attractive conditions. This could be solved through better information access and one-stop shops. In this regard, the example of the CliMalta in Box 3 was raised as a good approach for tackling awareness needs.

Box 3: CliMalta tool.

The CliMalta web tool

The CliMalta online tool was developed to help financial intermediaries (i.e., commercial banks) and final beneficiaries in Malta to determine the savings that a project could offer both in terms of financial savings and energy efficiency. This tool can further determine the eligibility of financing of projects thus facilitating access to finance for both houses and enterprises.

Figure 10: Capture of CliMalta online tool on the estimated savings for a hypothetical replacement of a gas boiler



The tool, based on a series of inputs provided by the user, shows estimated energy savings, renewable energy capacity generated, GHG emission reduction, and estimated annual financial savings. Above, the Figure 10 shows the estimated savings for a hypothetical replacement of a gas boiler produced between 1980 and 1990 with an Air source heat pump in a residential building of around 75 m^2.

The tool covers interventions such as insulation, replacement of windows and doors, other building envelope-related measures, space heating, lighting, domestic hot water, ventilation systems related to heat generation and recovery equipment, cooling, and integrated renewable energy.

Economic Barriers

Several economic barriers pose significant challenges to the implementation and success of heating and cooling projects. These barriers encompass various aspects of market dynamics, financial risk, and capital availability. Market risk, stemming from energy price fluctuations and reduced revenues for utilities due to more efficient networks, introduces uncertainty into project feasibility. Counterparty/offtaker risk and limited access to finance jeopardize project viability, while liquidity risk and long payback periods complicate operational matters. Furthermore, high upfront costs and excessive borrowing expenses hinder project initiation and sustainability.

WG 4 Participants outlined several economic barriers to investment for heating and cooling. While in the survey “Market risk” was not considered one of the main barriers for any of the TRL groups, **WG participants during the discussion noted the distorting effect of implicit and explicit subsidies on market forces,** which has been already discussed in the subsection on Policy, Regulatory and Social Barriers. For instance, the examples of Hungary and Croatia were raised, where the government through social subsidies shields consumers and households from market price fluctuations. This protection significantly reduces the attractiveness of new and more efficient heating and cooling system, as households and consumers would only see minor financial savings due to the artificially low prices of energy. There was a general agreement that **market price fluctuations are a bottleneck for energy investments**. In subsidized schemes, where energy prices remain stable, this concern may not apply. However, during periods of energy crises characterized by high price volatility, there's a clear incentive for renewable H&C solutions, aiming to mitigate the uncertainties associated with fluctuating gas and electricity prices.

The support for natural gas and electricity in the form of subsidies, as well as the local scale of district energy, can act as market barriers to the adoption of cleaner energy technologies. This way, governments are stepping up to accelerate clean energy innovation with multi-year R&D budgets, but flexibility will be needed to address evolving priorities and technologies. Ambitious government budgets for energy R&D and demonstration were announced in 2021, responding to national net zero pledges and the economic shock of the Covid-19 pandemic. While these concerns are most pronounced in the EU, they resonate strongly elsewhere as well, notably in the United States, China, India and Japan. The higher prices and revenues associated with fossil fuels can further hinder the development and adoption of clean energy substitutes.

WG4 member noted that lack of availability of finance & access to finance is also one of the primary economic barriers. The absence of public funding for test drilling, despite its critical role and high-risk nature in setting up geothermal systems, reflects a limitation in financial flows. This limitation stems from the fact that capital markets are not accustomed to financing certain types of investments, such as geothermal energy projects, and may not accurately price the associated risks**. As a result, the lack of available financing and risk mitigation mechanisms acts as a barrier to investment in geothermal energy initiatives.** The development and deployment of geothermal energy was identified as particularly relevant for the decarbonisation of heating and cooling, and therefore in need of important and significant financing. Participants mentioned the French approach to de-risking geothermal projects as a successful initiative, which is explained in Box 4.

Box 4: Geothermal in France

Geothermal risk mitigation system in France

In 1981, the French government decided to set up a system to cover geological hazards in order to facilitate the expansion pf geothermal energy usage in France. However, potential operators faced the lack of insurance products against geological risks. Initially, a system that offered both an incitement and a guarantee was set up directly under the authority of the Ministry of Industry. The mechanism put into place comprised a subsidy worth 30% of the cost of the first well, completed by a loan of 70% of this cost. The extra geological costs born of a random and unpredictable event during the works could also be covered.

Over the years, the levels of support provided varied, and the provision of finance was not continuous. Nonetheless, it is estimated that through this risk-mitigation system produced 34,360,000 MWh of geothermal energy and avoided the emission of over 6 million tons of CO_2 in the 1981-2015 period.

In 2015, the French government launched GEODEEP, a € 50 million risk insurance fund dedicated to deep geothermal energy, protect project operators against the geological risk faced during the exploration and exploitation phases.

Financing challenges are particularly pertinent to District Heating and Cooling (DHC) in general, with renewable projects facing heightened complexities due to greater investment costs as a proportion of total expenses over the project's lifespan compared to conventional heating technologies. Additionally, potential investors often perceive these unconventional approaches as riskier.[86]

WG 4 members discussed the impact of the **high upfront costs barriers** and the usefulness that some EU instruments (one of the examples presented in Box 5) that have had an effect in increasing the access to finance for heating and cooling projects.

Box 5: PF4EE

PF4EE

To support project promoters to deal with the high upfront costs and investment readiness, the European Commission and the European Investment Bank developed the Private Finance for Energy Efficiency (PF4EE) instrument. This instrument is deployed through financial intermediaries, acts as a one stop shop aggregating small projects to de-risk their portfolios and offers a portfolio-based credit risk protection, and long-term financing from the EIB, as well as technical assistance to increase their attractiveness to investors.

One of the examples of technology with higher upfront costs compared to traditional heating technologies are heat pumps. However, the cost-competitiveness of heat pumps compared to other heating technologies depends on a combination of factors, including the initial purchase price, operation and maintenance costs (including the price of the electricity needed to run them), their durability, and financial incentives such as grants or tax credits. In most markets, heat pumps generally entail higher upfront costs than conventional fossil fuel heating equipment such as oil or gas boilers, even when financial incentives are taken into account, but benefit from lower running costs over their lifetime due to their much higher energy efficiency. Today, the ability of heat pumps to compete on cost varies markedly across countries according to differences in all these factors. Based on average 2021 equipment prices and fuel prices projected in the Announced Pledges Scenario[87], a new heat pump used to heat an average-sized home in a cold climate is cheaper than a natural gas condensing boiler in most of the main heating markets, often even without subsidy. In some countries such as the United Kingdom, however, subsidies for heat pumps are required to make them cost competitive. Even where the cost of a heat pump over its lifetime is already the cheapest heating option, financial incentives, including grants and low -interest loans. These low-interest loans can make it financially feasible for building owners to install heat pumps, even if the upfront costs are high. By reducing the initial cost burden, these incentives can encourage the adoption of more sustainable heating solutions.

To summarize, to address the economic barriers the **suboptimal availability of funding and access to finances is needed.** This includes situations where **capital markets are not accustomed to funding certain types of heating and cooling projects and may struggle to accurately evaluate associated risks**. Additionally, market risks such as price fluctuations of heating fuels like gas, as well as long payback periods and high upfront costs, contribute to the difficulties in securing financial support for heating and cooling initiatives. These barriers hinder the development and adoption of more efficient and sustainable heating and cooling systems.

Energy market development

The development of the energy market faces various barriers, among which are challenges stemming from project size, investment readiness, supply chain deficiencies, and labour

[86] United Nations Economic Commission for Europe, *Overcoming barriers to invest in Energy efficiency*, 2017 (Link)

[87] Announced Pledges Scenario (APS) – Global Energy and Climate Model – Analysis - IEA

shortages. These obstacles include the high transaction costs associated with small-scale projects, the scarcity of investment-ready initiatives, disruptions in the supply chain and industrialization, as well as the need for upskilling and reskilling within the labour force due to the emergence of new heating and cooling technologies.

The **barrier of limited coordination** refers to **challenges in effectively aligning efforts and strategies across stakeholders involved in the heating and cooling sector, particularly within the European Union**. By focusing on an EU-wide heating and cooling market instead of solely local dimensions, there is an opportunity to enhance visibility, transparency, and coordination, thus incentivizing financing and fostering synergies. Discussions among WG 4 members emphasized the importance of EU-level coordination for cross-border heating and cooling projects to maximize benefits and streamline the heating and cooling supply chain across borders. Furthermore, barrier of limited coordination exacerbates the challenge of "scarcity of investment-ready projects" which stems from a lack of projects that are bankable or readily attractive to financiers, hindering effective alignment of efforts and strategies across stakeholders. By transitioning towards an EU-wide market approach, there is potential to address both barriers concurrently, as enhanced coordination can increase visibility and attractiveness of projects, thereby incentivizing financing and mitigating the scarcity of investment-ready opportunities.

Another major barrier is the **inadequate supply of labour** particularly for mature technologies and in a context of ageing population where retiring qualified workforce is not adequately replaced by new talents (see Box 6 on the importance of a skilled workforce for deploying clean energy solutions in the EU). The insufficient availability of workforce pertains to the innovative aspects of emerging heating and cooling technologies, demanding substantial upskilling and reskilling activities.

Box 6: Clean Energy Industrial Forum

CEIF Joint declaration on skills in the clean energy sector

Following the launch of REPowerEU, the Clean Energy Industrial Forum (CEIF) released a declaration[88] underlying the need for the EU to have access to a sufficient number of staff with the necessary skills to ensure a fast, steady, and equitable deployment of clean energy solutions.

The lack of workforce with adequate skills risks being a significant barrier to investments and is recognised as one of the most serious concerns by the industry. More precisely, CEIF identifies skills for the design, installation, and maintenance of renewable heating and cooling systems as one of the main categories of skills that are needed in the EU, and estimates that only solar heating and cooling will require additional 130,000 skilled workers by 2030, and other 400,000 will be needed in the heat pump value chain.

Technical Barriers

Technical barriers present critical challenges that impede successful implementation of heating and cooling projects. **Weak planning and preparation capacities** – and, thus, lack of technical skills and specific knowledge - among public authorities may result in unclear strategies for these investments. If a public authority lacks experience to evaluate and select high TRL advancement, they may struggle to write accurate tender documents or make informed investment decisions. This, in consequence, may complicate coordination with existing infrastructure and regulations, leading to challenges in supply-demand matching.

[88] Clean Energy Industrial Forum. Joint Declaration on skills in the Clean Energy Sector (Link).

Moreover, **technology risk** arises from uncertainties in the performance of emerging technologies and the competency of labour deploying them, while resource risk is associated with uncertainties regarding the availability, future price, and supply of renewable energy resources. Additionally, limitations in networks, distribution and infrastructure pose further challenges to the development of heating and cooling projects.

Nearly half of the buildings in the European Union have individual boilers that were installed before 1992, which have low efficiency level of 60% or less.[89] Many individual gas, oil, coal, and direct electric heaters are older than their technical lifetime, with efficiencies of 22%, 47%, 58%, and 34% respectively falling into this category. Replacing these old appliances is usually done under pressure when the heating system fails. However, the **lack of easily accessible information on pricing and existing system performance** makes it difficult for most consumers to compare solutions and leads them to continue using less efficient technologies.

Furthermore, lack of planning and preparation capacities within public authorities is compounded by factors such as insufficient transparency and awareness among stakeholders, ultimately obstructing effective coordination and the implementation of heating and cooling investments. **The complexity of permitting procedures, and continuity issues of projects do not allow stakeholders to have full awareness of the value of the solutions provided, thus hampering effective coordination between agents**. The lack of awareness slows the adoption of efficient systems by homeowners and deters industrial entities from investing in more efficient and renewable solutions.

Another barrier, which is related to technology risk is a crucial obstacle that hinders the development of emerging and mature energy technologies. It is associated with the **uncertain future performance of nascent technology.** One of the relevant examples is **geothermal risk mitigation** (see Box 5) previously discussed in subsection on economic barriers.

WG members found technology risk in H&C moderately relevant. This aligns with literature findings that emerging technologies carry higher risk than mature technologies and need to undergo further testing and standardization to reduce the risk of critical flaws.

Nevertheless, the barrier of technology risk affects both emerging and mature energy technologies. **For emerging technologies,** such as novel renewable energy systems or innovative heating and cooling solutions**, technology risk arises due to their uncertainties in performance, ongoing testing, and refinement, which rises concerns about their reliability in the long-term. Mature technologies**, despite having established themselves in the market, still face uncertainties related to their **ongoing performance, maintenance requirements, and compatibility with evolving industry standards and changing regulations**. Additionally, factors such as equipment aging, obsolescence, or unforeseen operational issues can introduce new risks over time, impacting the reliability and efficiency of these technologies.

To conclude, the transition to sustainable heating and cooling systems encounters multifaceted barriers across economic, technical, political, social. Economic barriers, such as high upfront costs hinder investment and adoption. Technical challenges, including technology risks pose obstacles to the deployment of efficient technologies. Political barriers, such as regulatory complexities and weak planning capacities, impede effective policy implementation and coordination. Moreover, energy market development barriers, such as shortage of investment-ready or bankable projects constrain the growth of the sector.

Overcoming these obstacles necessitates a comprehensive approach, including financial incentives, regulatory reforms, awareness campaigns, and market-based mechanisms. These

[89] 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 Heating and Cooling EUR-Lex (europa.eu)

strategies are essential to facilitate the necessary investments and expedite the transition toward a more sustainable and environmentally friendly heating and cooling sector.

3. Mapping and benchmarking of energy financing schemes and investment products

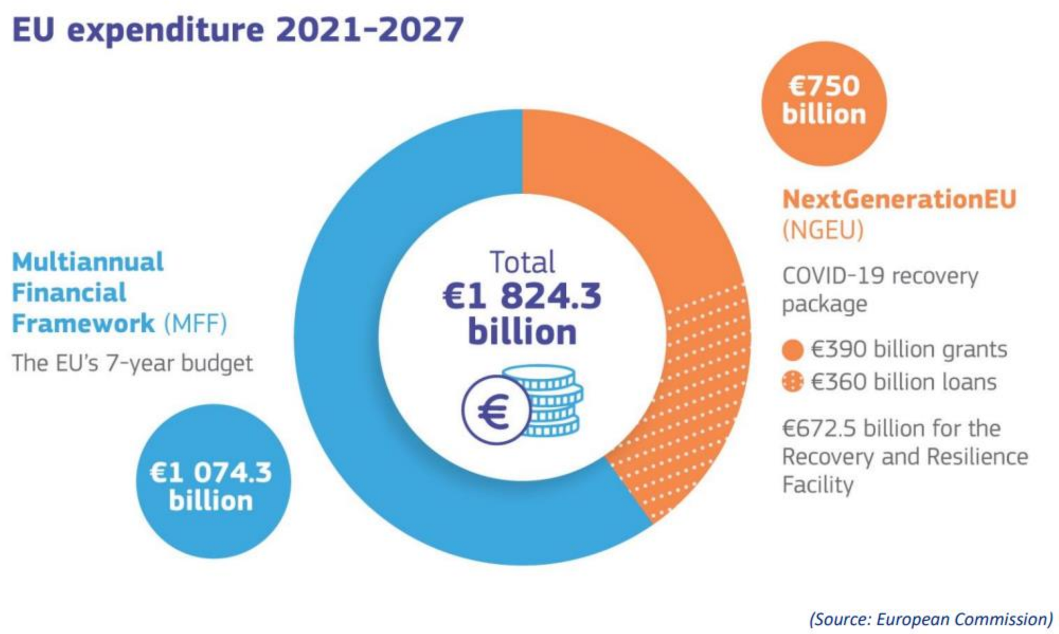
This chapter presents the financial schemes and programmes available for heating and projects in the EU. The first section comprises funding programmes at EU level, both under centralised and decentralised management that can be used to support energy production projects. The second section presents the instruments and schemes identified at Member State-level that are available for energy production based on the findings from the mapping exercise that was conducted.

3.1. EU financing programmes for H&C

The purpose of this section is to provide an overview of some existing financing instruments at the EU level, as well as EU funds allocated to individual Member States on H&C opportunities. The focus will be placed on instruments targeting and including the sector of heating and cooling to provide a view on available EU programmes and their disbursement practices.

EU leaders agreed on a comprehensive package of €1,824.3 billion, which combines the €1,074.3 billion long-term budget for 2021-2027, known as the multiannual financial framework (MFF), and an extraordinary €750 billion recovery effort, Next Generation EU (NGEU), so-called EU Recovery Plan- see Figure 11.

Figure 11. Schematic representation of EU expenditure for 2021-2027 encompassing MMF and NGEU.



Source: EU-Funding Opportunities, 2021-2027, A practical Guide Link.

EU targets of climate neutrality and independence from Russian gas require an unprecedented level of investment. The European Commission has reported an overall investment need of €210 billion (until 2027) to reach REPowerEU targets, among which H&C

have a core role. For example, 20 million heat pumps are estimated to be installed in the EU by 2026 and nearly 60 million by 2030 in order to meet the REPowerEU targets[90].

To support the green and just transition of the European continent, the European Commission has made it a priority to support the enhancement of development, construction, and operationalisation of energy projects through several funds and programmes, among which several opportunities for H&C can be found. Such programmes are either managed directly by the EC or by other EU bodies via *ad hoc* agreements. Starting from the MMF 2014-2020, the Commission has also adopted the Climate Mainstreaming approach, which requires all programmes – regardless of their policy area – to take climate issues into account. For the 2021-2027 period, the EU budget is expected to deploy €605 billion (30% of the overall budget[91]) for climate investments across different sectors and programmes. Overview of the major EU funding programmes related to climate actions is depictured in Figure 12.

Figure 12: Overview of the main EU funding opportunities Programmes related to climate action.

Innovation Fund	Funding innovative low-carbon technologies to reach climate neutrality in Europe.
Modernisation Fund	Modernising energy systems and improving energy efficiency in 10 EU countries.
LIFE Climate Change Mitigation and Adaptation	EUR 905 million to develop and implement innovative ways to respond to climate change.
Supporting climate action through the EU budget	EU has decided to integrate, or mainstream, climate action across the entire EU budget.
NER 300 programme	Funding innovative low-carbon technology, focusing on Carbon Capture and Storage.
International climate finance	EU supports climate action in developing economies across the world.
Call for Tenders	For example: Analytical capacity intl. climate action, ESR 2025 comprehensive review, etc.
Calls for Proposals:	Programmes of Horizon Europe: Climate Science, Energy Supply, Energy Use, Transport and Mobility Research. Programmes of EU Missions: adaptation to Climate Change, Restore our Ocean and Waters by 2030 and 100 Climate-Neutral and Smart cities by 2030.

Source: EU funding for climate action – European Commission (europa.eu)[92]

All the programmes funded by the EU budget fall under one of three types of implementation modes depending on the nature of the funding concerned:

1. **Direct management**: EU funding is managed directly by the European Commission
2. **Indirect management**: funding is managed by partner organisations or other authorities inside or outside the EU.
3. **Shared management**: the European Commission and national authorities jointly manage the funding.

In addition to these three management modes, this Study analyses programmes that are not financed from the EU budget but through the **EU Emission Trading System** (ETS)[93].

---

[90] EHPA, 2022 (Link)

[91] Climate Mainstreaming in the EU Budget: 2022 Update (Link)

[92] EU funding for climate action - European Commission (Link)

[93] European Commission. EU Emission Trading System. (Link)

Direct management

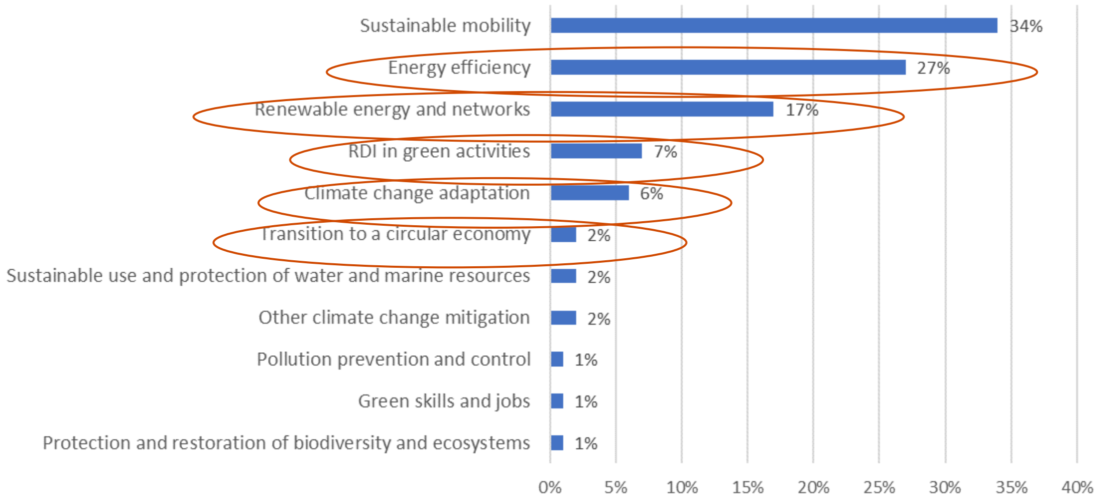
In direct management, the European Commission is directly responsible for all steps in a programme's implementation. These tasks are carried out by the Commission's departments, at its headquarters, in the EU delegations or through EU executive agencies; there are no third parties. Programmes implemented in direct management account for around 20% of the EU budget 2021-2027[94].

NextGenerationEU: the Recovery and Resilience Facility

The **NextGenerationEU**, is a temporary recovery instrument with a budget of more than €800 billion aiming to support Member States in repairing the economic and social damage brought on by the Covid-19 Pandemic and build greater resilience to face incoming challenges. At its centre is the **Recovery and Resilience Facility (RRF)**, a programme providing financing to enable Member States to increase resilience and prepare for their digital and green transitions. It has a total budget of €723.8 billion, out of which €385.8 billion take the form of loans and €338 billion of grants. To access these funds, Member States prepared tailored **National Recovery and Resilience Plans** (NRRPs) reflecting the allocation of the funds in each country and detailing the investment and reforms they plan on undertaking with the RRF resources to make their economies more sustainable, resilient, and digital by end of 2026. All 27 Plans have been officially adopted; however, some WG members noted that the timeline of the RRF is particularly tight for geothermal and DHC projects, thus making their financing more challenging.

The Facility is structured around **six pillars: green transition; digital transformation; social and territorial cohesion; health, economic, social and institutional resilience;** and **policies for the next generation**. Green transition is the pillar with the largest share of allocated RRF funds, amounting to 38.85% of the funds. Within the green transition pillar, energy efficiency, renewable energy and networks, RDI green activities, CCA and transition to a circular economy (red circles in Figure 13) all offer opportunities for H&C investments, covering up to 59% of the NRPPs share for the green transition pillar.

Figure 13: Breakdown of expenditure towards climate objectives per policy area (Pillar 1)



Source: RRF Scoreboard – Green Transition

The national recovery and resilience plans (NRRPs), through which the RRF is implemented, have a strong focus on energy, investing €88.5 billion (17.9 % of all resources) in this policy area. Specifically, the RRF Regulation includes investment in boosting energy efficiency, in housing and other key sectors of the economy, and in the clean energy transition and

[94] European Commission. Funding by management type. (Link)

networks: this includes high-efficiency co-generation, district heating and cooling. The decarbonisation of district heating systems through a more energy efficient heat production is supported in Finland's, Poland's Romania's and Slovenia's NRRPs[95]. Moreover, Germany has investing components focused on a higher RES share for H&C in buildings, while Austria has a district heating from biomass investment.

LIFE Programme

The **LIFE Programme** was originally created in 1992 to fund environmental projects and climate action. For the 2021-2027 programming period it will receive a total budget of €5.45 billion, whereby 1 billion is dedicated to the *Clean Energy Transition* sub-programme, focused at facilitating the transition towards an energy-efficient, renewable energy-based, climate-neutral and -resilient economy. Funds are allocated through yearly calls for proposals managed by CINEA. H&C projects are mainly co-financed under the **LIFE Clean Energy Transition** sub-programme in the following five areas of intervention:1) Building a national, regional and local policy framework supporting the clean energy transition; 2) Accelerating technology roll-out, digitalisation, new services and business models and enhancement of the related professional skills on the market; 3) Attracting private finance for sustainable energy; 4) Supporting the development of local and regional investment projects; 5) Involving and empowering citizens in the clean energy transition. The Climate Change Mitigation sub-programme funds cooling demonstration projects.

Horizon Europe

Horizon Europe (HE), the largest research and innovation funding programme in the EU, has an overall budget of €95.5 billion for the 2021-2027 period. Its resources are divided into four pillars and fifteen components. The *Climate, energy and mobility* (Cluster 5) Work Programme (€15 billion) particularly emphasises the role of renewable energy technologies in Destination "Sustainable, secure and competitive energy supply", highlighting that "*renewable energy technologies provide major opportunities to replace or substitute carbon from fossil origin in the power sector and in other economic sectors* ***such as heating/cooling****, transportation, agriculture and industry*". However, as analysed by the European Technology and Innovation Platform on Renewable Heating & Cooling (ETIP RHC) at the publication of the 2021-22 HE Work Programme, funding related to H&C could be more efficiently maximised with a specifically dedicated topic for R&I in the heating and cooling sector, as well as dedicated calls for renewable cooling, and market uptake measures dedicated to the renewable H&C sector[96]. The short time period between the call opening and deadline (e.g., the first calls of the 2023/2024 Work Programme) also prevent numerous and quality geothermal energy projects from being submitted.

Connecting Europe Facility

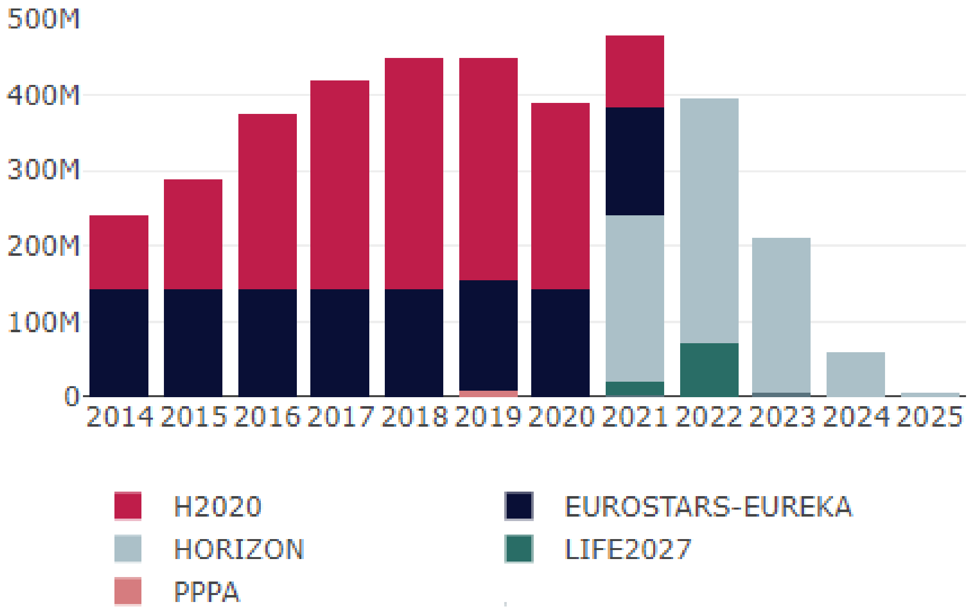
The **Connecting Europe Facility Cross Border Renewable Energ**y Programme is new in the 2021-2027 period and aims to fund cross-border projects in the field of renewable energy contributing to decarbonisation, to completing the internal energy market and to enhancing the security of supply. Heating and cooling projects (including geothermal infrastructure projects) are eligible. One of the additional benefits of the CB RES status apart from the eligibility for CEF funding is also the potential for increased investor certainty, However, a cooperation mechanism must be signed by two or more Member States (MS) or by Member State(s) and third Country(ies), which is a difficult criterion to fulfil for city heating and cooling projects. Figure 14 summarises the total budgets for H&C-related R&I projects from the five

[95] Energy policy in the national recovery and resilience plans, Next Generation EU Monitoring Service, European Parliamentary Research Service, October 2022

[96] ETIP RHC position on the official launch of the Horizon Europe Work Programme 2021-2022 (2021) (Link)

main EY programmes with earmarked resources for the subject of this paper. In all five cases, funding is provided in the form of grants.

Figure 14. Main H&C funding opportunities within EU funding programmes 2014-2025 (only already allocated projects



Source: Kaila.eu, 2023, budget in € M)

Indirect management

Some funding programmes are partly or fully implemented with the support of entities, e.g., national authorities or international organisations. The majority of the EU budget allocated to humanitarian aid and international development, for instance, is implemented under indirect management. Under this management mode, the Commission delegates budget execution tasks to different types of implementing partners.

InvestEU Programme

The **InvestEU Programme** combines thirteen centrally managed EU financial instruments[97] and the European Fund for Strategic Investments (EFSI) into a single instrument. As mentioned above, the program is structured around three blocks, of which one is under indirect management:

- *InvestEU Fund* (indirect management) which, through an EU budget guarantee of €26.2 billion, aims at raising more than €372 billion of public and private investments. The guarantee is deployed to back investments from selected implementing partners, with the EIB Group being the main one with 75% of the whole instrument. The guarantee supports investments in four policy windows: sustainable infrastructure, research, innovation, and digitalisation, SMEs, and social investments and skills. H&C decarbonisation and modernisation are specifically mentioned within the projects promoting the market deployment of low-carbon emission technologies.

[97] CEF Debt Instrument, CEF Equity Instrument, Loan Guarantee Facility under COSME, Equity facility for Growth under COSME, Innovfin Equity, Innovfin SME guarantee, Innovfin Loan Services for R&I Facility, Private Finance for Energy Efficiency Instrument, Natural Capital Financing Facility, EaSI Capacity Building Investments, EaSI Microfinance and Social Enterprise Guarantees, Student Loan Guarantee Facility, Cultural and creative sectors Guarantee facility

- *InvestEU Advisory Hub* (direct management) providing support and technical assistance;
- *InvestEU Portal* (direct management) brings together investors and project promoters on a single EU-wide platform, by providing an accessible and user-friendly database of investment opportunities.

Shared management

In shared management, both the European Commission and national authorities in Member States, such as ministries and public institutions, are in charge of running a particular programme. Around 70% of EU programmes are run this way. For what concerns the energy production sector, the European Regional Development Fund is the main relevant shared-management programme.

European Regional Development Fund

The **European Regional Development Fund (ERDF)** aims to strengthen economic, social, and territorial cohesion in the EU and to enable investments in greener and smarter practices. It functions through financing programmes in shared responsibility between the European Commission and national or regional authorities of Member States. Member States receive support for investments aligned with one or more of the ERDF's five policy objectives aimed at making the EU:

1. More competitive and smarter
2. Greener, low carbon and resilient
3. More connected
4. More social
5. Closer to citizens

The total budget of the ERDF is around €212 billion, to which around €97 billion of national co-financing by Member States should be added, for a total of around €308.8 billion[98]. A particularity of the fund is that less-developed regions will benefit from co-financing rates of up to 85% of the cost of the projects, while rates for transition regions and for more-developed regions will be up to 60% and 0% respectively.

Greener Europe is the Policy Objective with the second highest share of ERDF resources, €102.9 billion, second only to Smarter Europe with €112.95 billion. Through these resources, a significant number of national programmes have been financed in different Member States. Some of these programmes have been financed in full with ERDF resources, others have combined ERDF with other public resources. The Member States' administrations choose which projects to finance and take responsibility for day-to-day management. The ERDF specifically supports projects investing in replacing solid-fossil-fuel-fired heating systems with gas-fired heating systems to upgrade district heating and cooling systems or combined heat and power installations. Gas-fired heating systems are nonetheless eligible only until the end of 2025.

ERDF resources allocated for renewable energy (RS02.2) in the current 2021-2027 programming period amount to around €8.5 billion[99]**. Member States distribute these funds through various programs and schemes, employing different financing methods. Grants overwhelmingly constitute the primary form of financing for ERDF resources,** accounting for almost €7.5 billion**.** This includes approximately €450 million designated for

[98] European Commission. Cohesion Open Data Platform. Link

[99] Guarantee and equity and quasi-equity presented separately on the right for readability purposes.

grant components within financial instrument operations, with over €7 billion allocated to standalone grants. Loans account for around €980 million, whereas guarantees and equity represent the two least used types of financing, both respectively accounting for less than €30 million. Nonetheless, **growing use of financial instruments** is observed.

Just Transition Mechanism

The **Just Transition Mechanism** supports the fair transition to climate neutrality across the EU. For the 2021-2027 period it is expected to mobilise nearly €55 billion targeting industries and workers in most affected regions. The programme is structured around three pillars:

- ***Just Transition Fund**,* which aims to raise €25.4 billion of investments starting from a budget of €19.2 billion in current prices. The Fund mostly focuses on clean energy, and "district heating and cooling network lines newly constructed or improved" figure as direct targets actions covered by this fund.
- ***InvestEU "Just Transition" scheme***, providing – under InvestEU – a guarantee and an advisory hub with the objective of mobilising €10-15 billion, predominantly from private sector.
- ***Public Sector Loan Facility**,* managed by CINEA, which combines resources from the EU budget (€1.5 billion) with those provided by the EIB (€10 billion). It will also provide technical assistance under the InvestEU Advisory Hub. By blending these resources, the Facility aims to raise around €18.5 billion of public investments to be used by public sector entities. Within the PSLF, efficient district heating networks are one of the eligible fields.

Cohesion Fund

The **Cohesion Fund,** with a total budget of around €37 billion, supports Member States with lower gross national incomes in the field of environment and trans-European networks in the area of transport infrastructure. Around 37% of the overall budget is allocated to climate goals. District heating and cooling, replacement of coal-based heating systems and high-efficiency cogeneration are all included as specific targets of the fund.

ETS-based programmes

The European Union Emissions Trading System (EU-ETS) is a cap-and-trade system that aims to reduce greenhouse gas emissions in the EU by setting a cap on the total amount of certain greenhouse gases that can be emitted by installations in the sectors covered by the system, covering around 40% of the EU's greenhouse gas emissions[100].

The main impetus for the industrial sector to implement changes in reducing its greenhouse gas emissions comes indeed from the EU ETS. With the increased certificate prices the EU ETS is set to become a key driver for industries in their decarbonisation strategy, particularly those involved in heat usage and the production of heating and cooling plants.

Furthermore, the new ETS, introduced by the 2023 revision of the ETS Directive will cover also CO_2 emissions from fuel combustion in buildings, road transport and additional sectors (mainly small industry not covered by the existing EU ETS).

Auctioning is the default method of allocating allowances as of phase 3 of the EU ETS (2013-2020). The Member States auction their allowances in accordance with the Auctioning Regulation and the ETS Directive, under which Member States should use at least 50% of their share of the auctioning revenues for climate and energy-related purposes. The

[100] https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/auctioning_en

Modernization Fund and the Innovation Fund are funded with the EU's share of the auctioned allowances.

Modernisation Fund

The **Modernisation Fund** was set up by the European Commission to support the ten lower-income Member States[101] in their transition to climate neutrality and to increase energy security. The Fund supports investments in energy production, energy efficiency, energy storage, modernisation of energy networks, and just transition in carbon-dependent regions.

The Modernisation Fund is an ETS-based instrument and not an EU budgetary programme. **It is funded from revenues from the auctioning of 2% of the total CO_2 allowances** for 2021-2030 under the EU ETS. At the price of €75/tCO_2, the total budget of the MF amounts to around €48 billion from 2021 to 2030, but this amount can change depending on carbon prices[102]. In addition to the MF budget, beneficiary Member States can transfer additional allowances from other programmes under the ETS system. This can further increase the financial resources available to Member States to finance energy transition. To date, five Member States (Croatia, Czech Republic, Lithuania, Romania, Slovakia) have opted to do so. **Poland, Czech Republic, and Romania are the three biggest beneficiaries of the MF**, with shares of 43.4%, 15.6%, and 12% of the total allowances, respectively.

The fund includes support investments in energy storage, generation and use of renewable sources and modernisation of energy networks, including pipelines, grids and **district heating**, as well as just transition in carbon dependent regions. **Different Combined Heat and Power (CHP)/District Heat and Cooling (DHC)** projects have been already funded at Member State level via the revenues from the auctioning of 2% of the total allowances for 2021-30 under the EU Emissions Trading System (EU ETS).

On May 2023, the revised EU ETS regulation was published in the Official journal of the EU[103]. The revised regulation strengthens the System and extends the ETS to new sectors of the economy, such as buildings, road transport and shipping, and to three additional Member States: Portugal, Greece and Slovenia. This will result in the Modernisation Fund to increase its size.

Innovation Fund

The **Innovation Fund (IF)** is expected to provide €38 billion[104] between 2020 and 2030 for the commercial demonstration of innovative low-carbon technologies. This scheme is funded by the EU Emissions Trading System, so the exact amount of funding will ultimately depend on the carbon price. The fund is managed by CINEA and resources are allocated through regular calls for proposals for both large and small-scale projects[105], also revised in light of the REPowerEU strategy last year. Examples of funded IF projects include small-scale (< €7.5 million) pioneering solutions to provide energy where district heating or cooling infrastructures are absent. However, to date, there are no pure DHC projects financed with the IF.

The European Investment Bank Group

Aside to the financing instruments of the EC and its agencies, the **European Investment Bank Group** (composed of European Investment Bank and European Investment Fund) also plays a central and key role in the energy financing landscape, including the H&C area. While the EIBG does not have specific investment programmes or schemes for energy, in its **energy**

101 Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia.

102 https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/modernisation-fund_en

103 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2023:130:TOC

104 Estimated assuming a carbon price of €75/tCO2

105 For small-scale projects are intended all those with total capital costs under 7.5 million

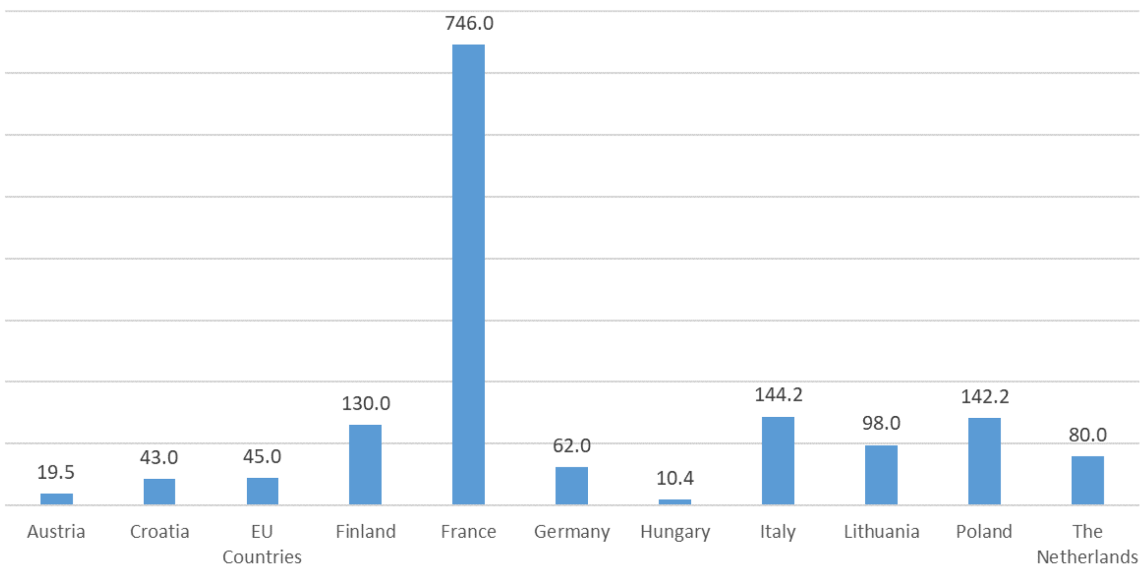
lending policy[106], one of the key areas of intervention is the **decarbonisation of the energy supply**. This consists of supporting the deployment of renewables as well as investing in new and more innovative technologies.

When looking at data from the energy projects financed directly by the EIB, several large-scale projects on H&C can be mentioned: last year, the Advanced Heating System project was funded, with €120 million in loans going to Vaillant Gmbh through France, Germany, Slovakia, Spain[107]. Engie's Green Capex Program has also received 525 € million this year, with the project about to kick-off in France[108].

The Figure 15 provides an overview of the volumes of direct financing provided by the EIB between 2017 and 2022 to H&C projects, mostly district heating networks. As can be noticed, France is the country that received the most direct financing, followed by far by Italy, Poland and Finland.

One thing that should be taken into consideration when looking at these numbers is the different configuration of Member States' heating and cooling systems. Some EU countries mostly rely on district heating systems, which are larger infrastructure projects that are, therefore, more likely to receive direct support from the EIB or other development financial institutions. On the other hand, in the EU there are also several countries that mostly rely on individual heat pumps (at building and/or household level). Being much smaller investments, financing to heat pumps usually falls under the scope of financial support schemes for energy efficiency and building refurbishment and are less suited for direct financing from public sector entities.

Figure 15: EIB direct financing to H&C projects between 2017 and 2022 (in € M)



Source: PwC analysis of eib.org data

Another European Investment Bank programme run with the European Commission and centred on preparing energy efficiency projects is **ELENA**, the European Local ENergy Assistance facility. ELENA's grants pay for actions that help develop projects, such as feasibility studies, programme structuring, business plans, energy audits, and the preparation of tenders and contracts. It has already provided more than €168 million in grants for technical assistance on energy efficiency and renewable energy in buildings, homes and urban transport. One remarkable ELENA's project in Ljubljana targeted

[106] EIB. Energy lending policy. https://www.eib.org/attachments/strategies/eib_energy_lending_policy_en.pdf

[107] Advanced Heating System project https://www.eib.org/en/projects/all/20210505

[108] Green Capex Program project https://www.eib.org/en/projects/pipelines/all/20220653

the renovation of its public budlings stock aimed at lowering its district heating costs. In Ireland, the programme allows to implement energy audits and feasibility studies for hundreds of energy renovations in private homes, helping residents install and replace older heating systems with modern heat pumps. In Austria the Programme is financing the preparation of two investment projects which will make significant contributions to the decarbonisation of the district heating system in Vienna [109].

The EIF also invests in the energy sector, whilst not directly but thorough other funds. Under the InvestEU equity product, EIF seeks to increase the availability of risk capital across all stages of company development, accelerating growth of European scale-ups accompanying and supporting them in accessing public markets, as well as other EU policy objectives. **Under the InvestEU Climate & Infrastructure Product, the EIF provides equity investments to, or alongside, climate & infrastructure funds** investing in, among others, decarbonising heating and cooling infrastructure (including networks) in buildings or other facilities [110].

The Marguerite Fund is a pan-European initiative worth mentioning. Marguerite is an equity fund launched in 2010 and **backed by the EIB and the five National Promotional Banks** of Italy, Poland, Spain, Belgium, and Germany. It acts as a catalyst for key investments in energy (renewables, hydrogen, low-carbon gasses, T&D, storage) and transport. It is the first fund of its kind launched by Europe's leading public financial institutions following an initiative endorsed during the second half of 2008 by the Economic and Financial Affairs Council and the European Council as part of the European Economic Recovery Plan[111]. The first fund, the Marguerite I, gathered €710-million worth of commitments, and the Marguerite II reached €745 million.

Maturity stage covered

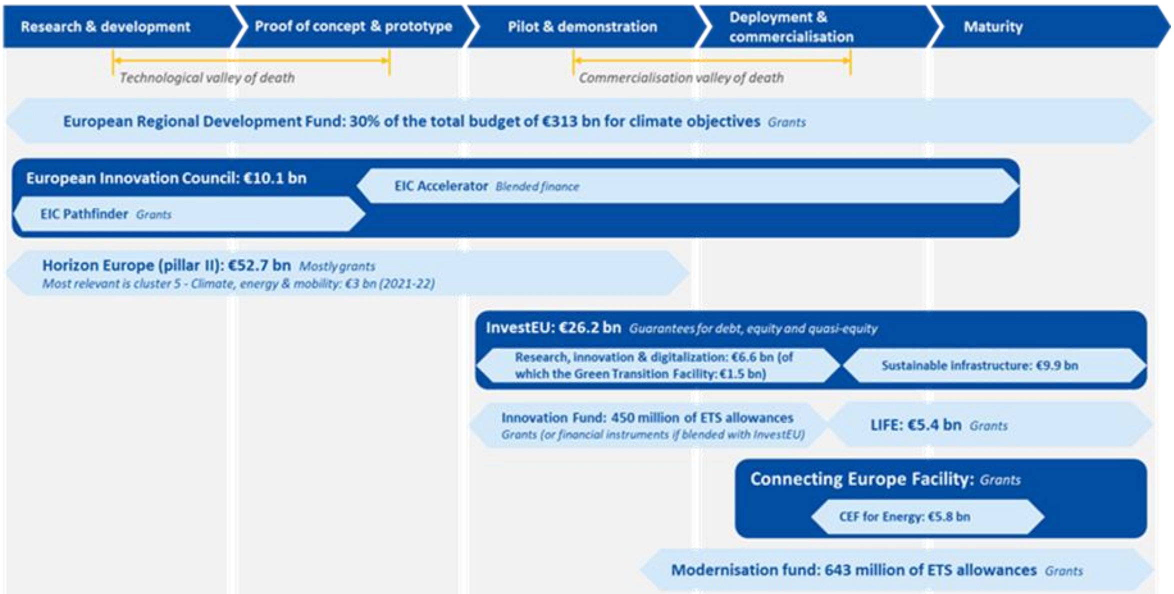
Centralised EU financing programmes target beneficiaries and projects at different levels of maturity and TRLs, aiming to address their specific barriers to investment. By focusing on different TRLs, programmes can better address the barriers to investment relevant for different maturity stages. As can be seen from the Figure 16, EU financing programmes provide complete coverage across different stages of maturity. For less mature technologies still in the research & development stage, Horizon Europe and the EIC Pathfinder provide support primarily in the form of grants, which tend to be the most suited type of financial support for technologies that are still far from commercial maturity. The EIC Accelerator, the Innovation Fund, and InvestEU's RDI investment window provide then support for more developed technologies, which are nonetheless still not fully mature. This support comes in the form of blended finance, grants and guarantees for debt and equity financing. Finally, InvestEU's Sustainable infrastructure window, the LIFE Programme, CEF, and the Modernisation Fund provide financial support for mature technologies, in the form of grants and guarantees.

[109] https://www.eib.org/en/products/advisory-services/elena/index.htm

[110] EIF. Climate & Infrastructure Funds. https://engage.eif.org/investeu/climate-infrastructure-funds

[111] EIB. Marguerite Fund. https://www.eib.org/en/products/equity/funds/marguerite-fund

Figure 16: Overview of EU financing programmes according to their targeted TRL levels.



Within the wider sector of renewable energy, H&C is similarly characterised by projects covering a wide variety of innovative solutions, as well as the modernisation and upgrade of mature technologies. EU programmes are nonetheless able to support projects in H&C with different TRLs through a technology neutral approach. All the programmes previously mentioned are **technology neutral, as there are impact-based**.

3.2. Financial support schemes at Member State Level

To address the challenges faced by heating and cooling projects and to enhance investments in heating and cooling to achieve policy goals, the public sector can implement different financial support schemes. Financial instruments not only improve the financing conditions for a specific type of project (e.g., by de-risking it, increasing the financing available, improving the financing conditions, etc.), but also send a strong signal to market players about governments' and public authorities' commitment to that sector.

A mapping exercise was conducted to gather an overview on the existing financial support schemes available for energy projects, including heating and cooling. The purpose of the mapping was to assess the current availability of instruments and schemes to support heating and cooling projects, in order to assess to what extent they are effective in addressing barriers and mobilising additional finance. This will prove to be useful and functional for the development of future financial support schemes to support the energy transition in the EU, both new instruments or existing one being continued and improved.

Financial support schemes are not the solution for all barriers and bottleneck faced by energy projects. They are the most relevant to address barriers stemming from financial and market conditions, and less suitable for social and regulatory ones. This relevance is further explored in section 4.1.

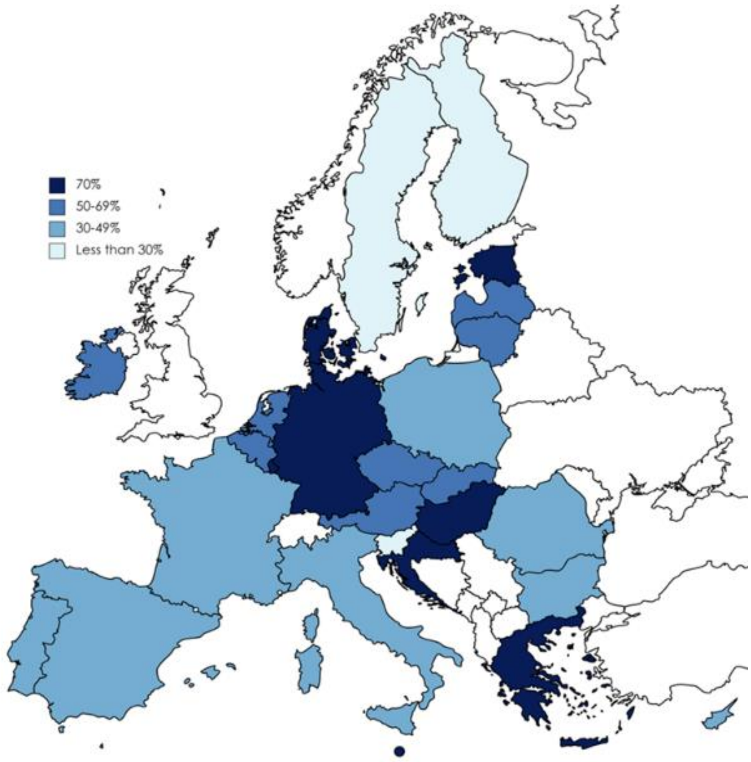
The mapping was conducted through a combination of **desk research and interviews** with selected stakeholders to obtain complementary information. Instruments were categorised by segments of the energy value chain they can support, eligible beneficiaries, targeted development phase, and type of financing provided (see Annex 1). Some instruments have been flagged as **relevant for more than one single dimension**. These instruments were categorised under all the relevant categories, to reflect the scope of the instrument. This note should be kept in mind when reading the data presented below as, for instance, when it is stated that 74% of mapped instruments in Greece target heating and cooling, it does not mean that 74% of all the mapped instruments target only heating and cooling, but that they target also energy heating and cooling and none of the mapped instruments do not target it.

Instruments targeting solely energy efficiency (e.g., for the renovation of buildings, for industries, etc.) – albeit particularly popular – have been excluded from the analysis, as already covered by the work on the Energy Efficiency Financial Institutions Group. Energy efficiency instruments were mapped only if they included also support for transmission and distribution. For the purpose of the analysis and to identify regional trends, EU Member States have also been aggregated in four geographical areas, following the classification from EuroVoc[112]: Central and Eastern Europe[113], Northern Europe[114], Southern Europe[115], and Western Europe[116].

General overview: heating and cooling instruments

The mapping has produced a database of 564 instruments across the 27 EU Member States. Poland (43), Italy (41) Germany (39), and France (35) are the three four countries in which the highest number of identified instruments. On the contrary, Denmark (10), Cyprus (10), and Finland (9) are the countries with the lowest number of identified instruments.

Figure 17: Share of heating and cooling instruments out of the total mapped



On average, **around 54% of the mapped instruments supports heating and cooling, 300 in total**. However, out of these that have been identified as available for this segment, **just 12 are targeting only heating and cooling** (for further information see Box 7 and Box 8). Additionally, **34 of them support H&C and another segment** (Production 25 times, Transmission and Distribution once, Services and Prosumers 8 times). Finally, 171 instruments support all the five segments (energy production, transmission and distribution, energy storage, heating and cooling, and services and prosumers).

All EU Member States present at least 1 instrument supporting heating and cooling. 8 Member States (Croatia, Denmark, Estonia, Germany, Greece, Hungary, Luxembourg, and Malta) have a share of instruments supporting heating and cooling which is equal or higher than 70%. On the contrary, only in Slovenia such ratio is lower than 20% (see Figure 17, Figure 18 and Figure 19). **Instruments which only target heating and cooling**

112 Available on: https://www.researchgate.net/figure/European-subregions-defined-by-EuroVoc-Blue-Northern-Europe-green-Western-Europe_fig1_321354391

113 Bulgaria, Czech Republic, Croatia, Hungary, Poland, Romania, Slovakia, Slovenia

114 Denmark, Estonia, Finland, Iceland, Latvia, Lithuania, Norway, Sweden

115 Greece, Italy, Malta, Portugal, Spain

116 Austria, Belgium, France, Germany, Ireland, Luxembourg, the Netherlands

have been found in 8 Member States, namely Belgium, Czech Republic, Denmark, Hungary, Netherlands, Poland, Slovenia, and Spain.

The mapping also looked for information about the **volumes of financing** provided. Information about the total budget of the instruments as well as the amount already deployed have been collected where available, to understand what the available magnitude of financing for different target groups is and how it is channelled through different funding instruments/financial schemes. However, the mapping was able to gather only partial information on volumes, as such data was publicly available for less than half of all instruments relevant for heating and cooling (126 instruments of the total 300 instruments) and information on deployment was missing in most of the cases.

Figure 18: Instruments mapped per Country

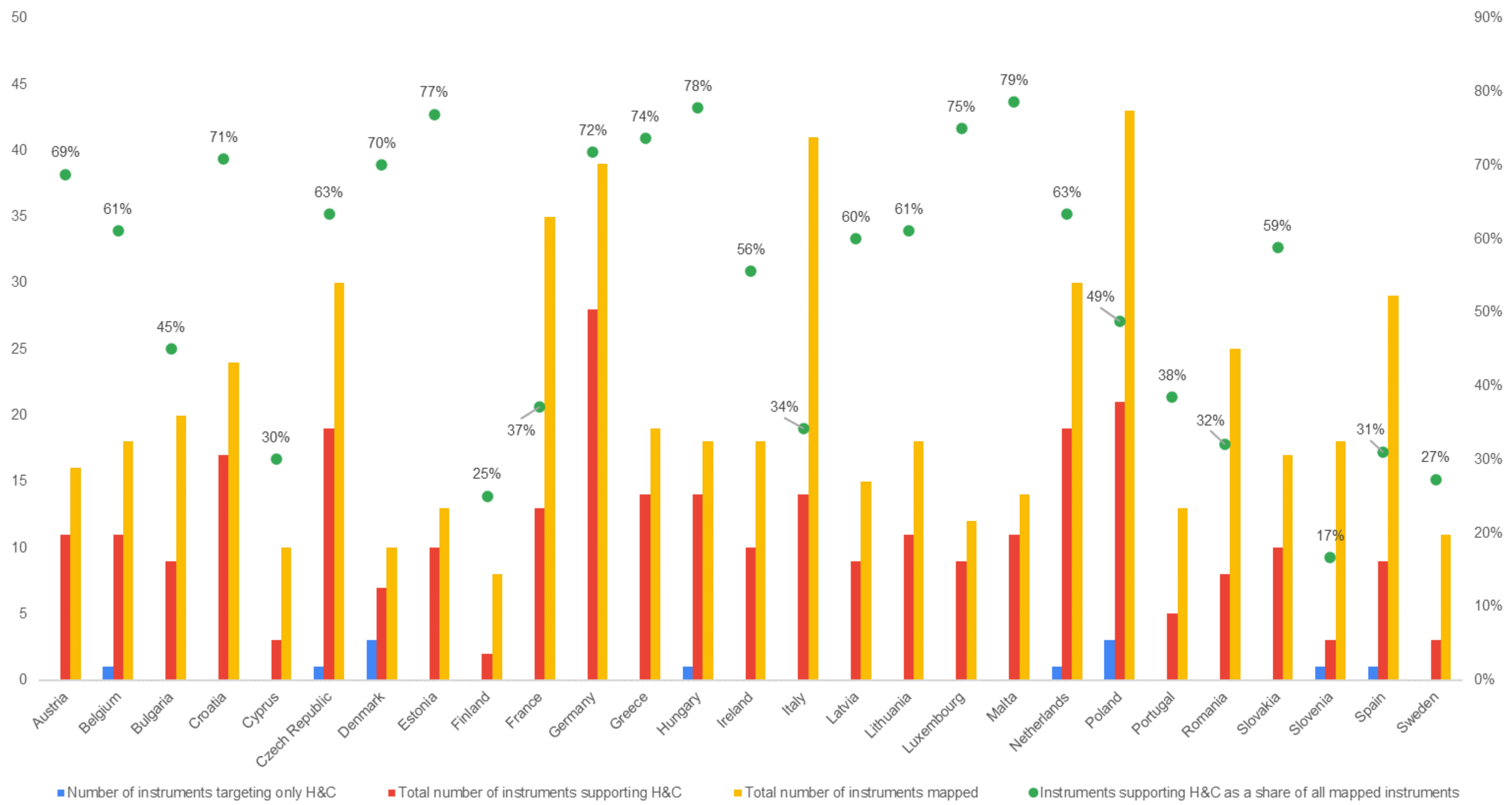
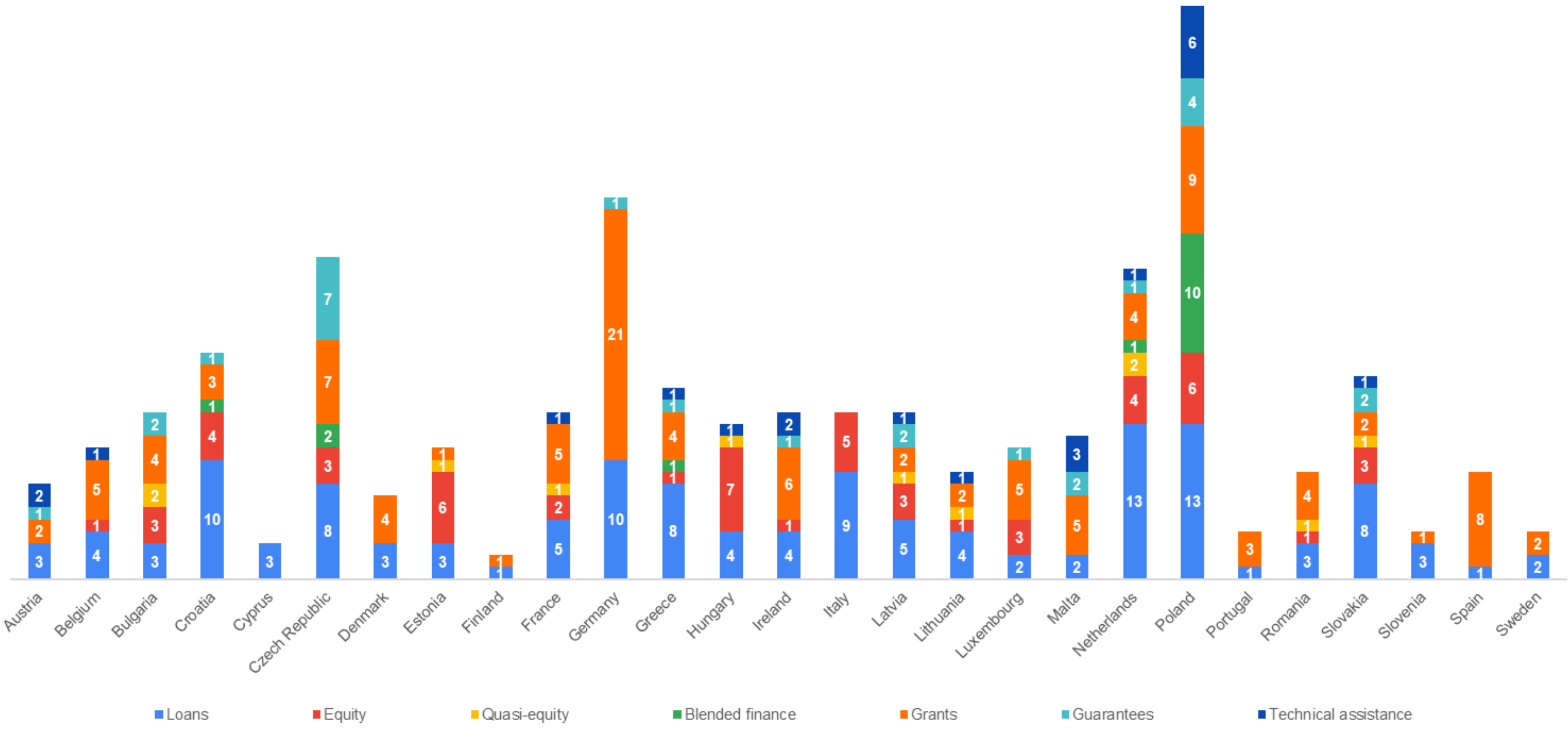


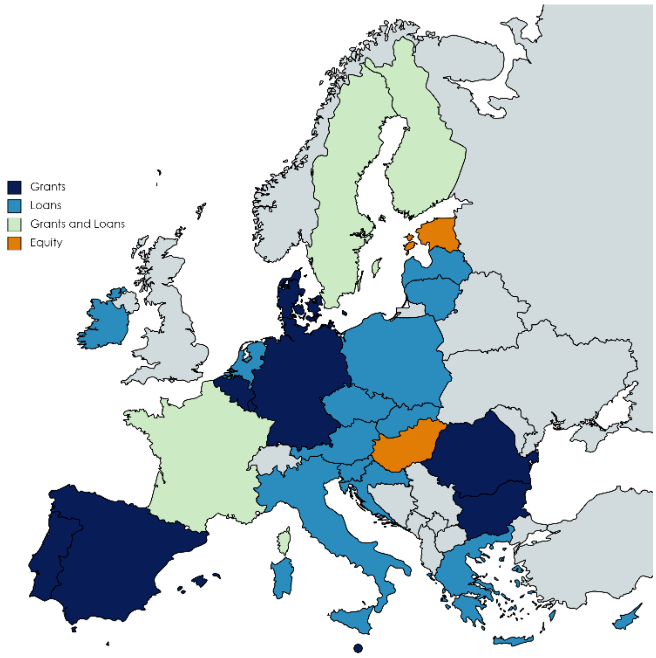
Figure 19: Number of financial instruments for heating and cooling per country and per type of instrument



Financing Instruments by type

Loans and grants are the most widespread across the set of 300 instruments that the mapping identified as relevant for heating and cooling. Only in Hungary and Estonia equity instruments are the most widely available (see Figure 20).

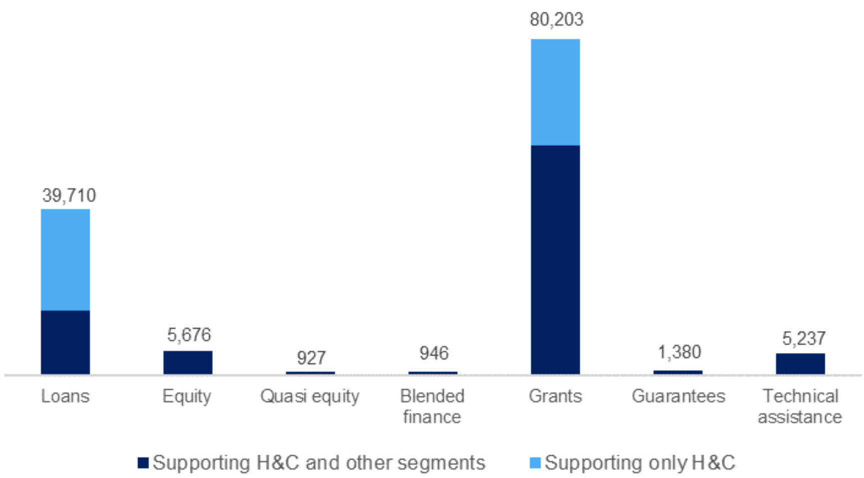
Figure 20: Most mapped type of instrument per country



On aggregate, **a total amount of around €126 billion has been estimated to be available inter alia for heating and cooling projects by taking into account the resources coming from the EU, national public authorities, and private institutions.** As displayed in the Figure 20, overall, the amount allocated to grants, €80 billion, is twice the size of what is allocated to loans (€39 billion). **Out of these amounts, around €50 billion are channelled through H&C-only instruments (€25 billion through loans, €25 billion through grants).** For guarantees, the maximum leveraged investments due to the respective guarantee has been considered for the calculation, and not the number of guarantees disbursed, which was not available. These estimates are based on information for 126 instruments.

These volumes also include the total volume of instruments targeting also but not only heating and cooling, and for which there is no specific pre-allocation. This means that these volumes are not guaranteed to be spent in heating and cooling only. Additionally, some schemes for which it was impossible to determine the exact type of instrument through which money will be deployed are excluded from the break-down Figure 21 which follows.

Figure 21: Volume of financing per type of instrument (€ M)



The mapping identified a total of 110 grants supporting heating and cooling and **Germany is the country with the highest number of registered grant instruments** (21). This data is explained by the fact that many of these schemes come from the investment arms of the Länder, reflecting the federal governance of the country.

Box 7: Focus on: Grants for heating and cooling only.

Grants represent around the 75% of the 12 mapped instruments supporting only heating and cooling, for a total of 9 schemes. The mapping identified H&C-only grants in Bulgaria, Czech Republic, Denmark, Poland, Slovenia, and Spain.

In general, **all these measures refer to the installation of clean heating systems**. In some cases – as in Denmark – there is also an explicit reference to expanding and strengthening district heating.

Most of H&C-only mapped grants are funded (either entirely or partially) **by EU programs** (7 out of 9). Investments in Poland and Czech Republic have been financed thanks to the Modernisation Fund while the others usually rely on resources coming from the national RRF.

As previously mentioned, **around €25 billion is being channelled specifically for heating and cooling projects through such support schemes**.

Most mapped resources will be available through the Polish **Clean Air Programme**, aimed at improving air quality and energy efficiency and reducing greenhouse gas emissions both at the individual level and for public buildings. **The overall goal of this intervention is to phase out coal by 2030 while increasing the amount of zero emission houses to 3 million with new low emissions heating sources and low-emission public buildings**. With a total budget of PLN 103 billion, the Plan is built on three pillars:

- Clean Air. Under the form of a grant, it incentivizes citizens to switch to more sustainable heat sources.
- Stop Smog. Granting up to 70% of the overall costs for municipalities that are planning to switch to cleaner heating sources.
- Thermo-modernisation relief. For buildings which have a weak thermal protection and bad central heating.

Signed in 2018, this ten-years programme is a collaboration between the Polish National Fund for Environmental Protection, 16 regional Environmental Protection Funds and the National Environmental Protection Bank.

Loans (135 in total) come mostly from market-oriented public institutions such as national promotional banks (NPBs) or the EIB Group and we found them across all Member States.

Some products coming from private banks and funds are also present. Loans are prevalent in all geographic areas and no specific differences or trend was identified. Poland (11), the Netherlands (11), Germany (10) and Croatia (10) are the countries with the highest number instruments.

Box 8: Focus on: Loans for heating and cooling only.

Loans represent around half of the 12 mapped instruments supporting only heating and cooling, for a total of 6 schemes. In three occasions, the loans were part of a more complex programme combining both debt and grants. The mapping identified H&C-only loans in Bulgaria, Hungary, the Netherlands, Poland, and Slovenia.

In general, **all these measures refer to the installation of clean heating systems**. In some cases – as in the Netherlands – there is also an explicit reference to expanding and strengthening district heating.

A half of H&C-only mapped loans are funded (either entirely or partially) **by EU programs** (3 out of 6). As previously mentioned, **around €25 billion is being channelled specifically for heating and cooling projects through such support schemes**. The largest program is again the Polish Clean Air Programme described in Box 7, for which it was impossible at this stage to estimate the exact share of resources coming from grants or loans.

The second largest investment overall is instead represented by an EIB Programme Loan for the heating sector in Poland. With a proposed EIB financing of €94 million and a total cost of €700 million, such intervention intended to fund several sub-projects implemented by promoters active in the district heating sector. More specifically, the objective was to fund CAPEX investments for both new generation and distribution assets as well as the refurbishment of existing facilities.

The mapping found 54 equity instruments, across 16 EU countries[117]. Hungary is the country with the highest number of equity instruments identified (7). **There are no equity instruments targeting exclusively heating and cooling.**

While there is still a diffused lack of awareness about the nature of the H&C sector**, equity investors are increasingly getting familiar with the business models of H&C companies.** Until recently, H&C solutions were hard to sell, but since few years WG members noted that the market is evolving and now **the H&C sector is slowly becoming more liquid and mature for equity investments**.

When discussing the different types of equity financing, WG members noted that **private equity tends be the most suitable form of equity for H&C projects, since they are a good fit for mid-mature stage portfolios and require long term investors and long-term performance.**

Quasi-equity, which is a more complex financial instrument, is less present and was found in 9 Member States[118]**, for a total of 11 instruments**. On the other hand, **55 instruments can be categorized as blended finance**[119]. None of them, however, is specific for heating and cooling. Such schemes have been mapped in 18 Member States[120] with Poland (12 instruments) being by far the country with the largest availability. **The provision of more sophisticated financial instruments such as (quasi)equity and blended finance require a high degree of cooperation between public and private providers of finance.**

---

117 Belgium, Bulgaria, Croatia, Czech Republic, Estonia, France, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Romania, Slovakia

118 Bulgaria, Estonia, France, Hungary, Italy, Latvia, Netherlands, Poland, Slovakia

119 For the purposes of this study, blended finance refers to financing solutions that encompass a mix of different types of financial instruments in a structured and calibrated way, tailored to the investment profile. The funding sources can be either purely public or combination of public and private funding.

120 Austria, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, France, Germany, Greece, Ireland, Latvia, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania

Most of the identified instrument are provided by or in cooperation with NPBIs and the EIB Group.

One or more guarantee schemes for heating and cooling are available in 13 EU Member States[121]**, for a total of 26.** Czech Republic has 7 instruments, followed by Bulgaria with 4, while the all the other countries only have 1. In the majority of the cases, guarantees are provided by the public sector, especially through facilities financed by the EIB Group or EU funds.

As remarked by WG Members, **guarantees are a type of instrument that is less available for the heating and cooling segment** especially in some countries**,** leading to some funding gaps. Additionally, **the uncertainty around the long-term availability of guarantee schemes is a major barrier for investors** since they cannot access beforehand if a certain scheme is going to be available for the entire duration of the selected project.

Finally, **21 instruments also including technical assistance have been mapped across 12 MS**[122]. Poland is the country in which Technical Assistance is provided the most. In 12 occasions this instrument was paired with loans. 9 times it was offered together with a grant. In 5 occasions instruments were offered together, alongside technical assistance. Overall, as showcased above, the volume of money channelled through programs, mostly loans and grants, that come with a technical assistance part is around €5 billion.

According to WG discussions, **technical assistance is often necessary when investors have limited knowledge about the H&C. TA is crucial especially for public-owned companies, where the public sector might not have specific knowledge and skills**. In the case of large-scale H&C projects, business planning and financial bankability could benefit from TA since they are often not as developed as private investors would require.

Box 9: Focus on: Bonds financing for energy and sustainable activities

1,960 or around 58%, of all GSSSBs of EU issuers between January 2015 and February 2023 were relevant for renewable energy. The following figures will focus on the **use-of-proceeds bonds** (i.e., Green bonds, social Bonds, Sustainability Bonds, **1915 in total**) which had renewable energy as one of the declared uses of proceeds[123, 124]**.**

Heating and cooling are not a use-of-proceeds category that is used in the issuance of green bonds. Therefore, it was not possible to identify and analyse green bonds based only on their relevance for heating and cooling. When heating and cooling is an eligible category, it is included under the broader umbrella of “Renewable energy”. For this reason, the following analysis focuses on GSS bonds for renewable energy.

The EU has been promoting green bonds as a way to support its Green Deal, which aims to make the EU climate-neutral by 2050. The EU has also developed a taxonomy for sustainable activities, which defines which economic activities are environmentally sustainable and can be eligible for green financing. The EU has recently adopted a regulation creating a European Green Bond Standard (EUGBS), which is a voluntary

[121] Bulgaria, Croatia, Czech Republic, Germany, Greece, Ireland, Latvia, Malta, Netherlands, Poland, and Slovakia

[122] Austria, Belgium, France, Greece, Hungary, Ireland, Latvia, Lithuania, Malta, Netherlands, Poland, and Slovakia

[123] Based on data from Environmental Finance retrieved on 29 March 2023.

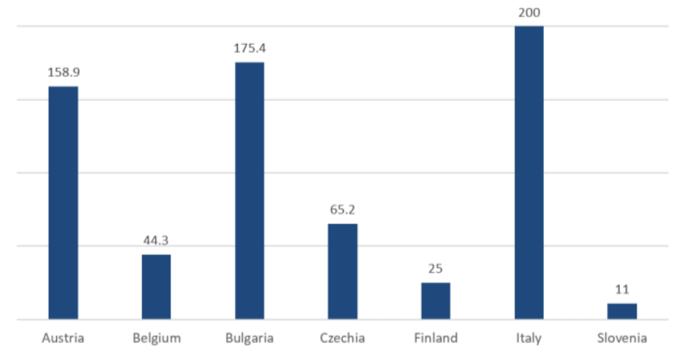
[124] For EU companies that have operations outside the Union, as well as for DFIs, a non-quantifiable of the raised funds may have been directed towards projects in extra-EU countries

framework that sets out the requirements and criteria for issuers of green bonds in the EU. The EUGBS is aligned with the EU taxonomy and ensures transparency and consistency in the green bond market. The EUGBS also establishes a registration system and supervision framework for external reviewers of European green bonds, to prevent greenwashing and ensure high standards of quality and credibility. The EUGBS will apply to all issuers of green bonds in the EU, regardless of their size or sector. However, there is some flexibility for sectors that are not yet covered by the EU taxonomy or certain very specific activities, such as energy efficiency or renewable energy projects. These sectors will have a 15% flexibility pocket in their use of proceeds from European green bonds, which will be re-evaluated as the transition towards climate neutrality progresses[125].

Green Bonds are expected to be an increasingly important instrument to finance sustainable activities over the next years. In the last decade in the EU, both public and private sector entities have started tapping the green bond market, following the increasing attention to sustainable finance. Although China has been in 2022 the largest global issuer by number of issuances, the European market remained the largest in terms of issued volumes, with a supply of around $219.03 billion. Historically, European entities have been pioneers in this field, with the EIB being the first issuer of a green bond in the world back in 2007.

The Commission is funding up to €250 billion (or 30%) of NextGenerationEU by issuing NextGenerationEU Green Bonds. By analysing Member States' National Recovery and Resilience Plans, it is possible to observe that around **€680 million of planned expenditures in H&C investments/schemes are eligible to be financed through the UoP of NGEU Green bonds**. As can be seen in Figure 22, Italy is the country with the highest eligible amount in H&C expenditures to be financed with proceeds from the NGEU Green bond issuance. It is followed by Bulgaria and Austria.

Figure 22: NRRPs H&C expenditure eligible for NGEU Green Bonds proceeds by MS (in € M). Source; Based on Report WG4 N6 "Green Bonds "



Corporate bonds

Sweden has the highest number of issued corporate UoP whose proceeds are entirely or partially earmarked for renewable energy projects among all Member States. This result is largely due to the high number of issuances from real estate companies and housing associations, which account for more than 80% of the total Swedish issuances (see Figure 23). **Spain ranks second with 83 bonds in total**, and it leads in terms of the number of issuances from energy sector companies (68).

[125] European Green Bonds: Council adopts new regulation to promote sustainable finance - Consilium (europa.eu)

Germany ranks third overall, with a total of 70 issuances, including 48 from energy sector companies.

Corporates issued around €216 billion of UoP bonds with proceeds designated for financing renewable energy projects. German and French companies have issued just around €35 billion each, with an average issuance of around €510 million and €662 million, respectively. The Netherlands and Spain are next, with €28 billion each, and average issuances of €535 million and €340 million, respectively. On the other hand, Swedish companies issued only around €21 billion, with an average issuance of just €66 million (see Figure 24).

Figure 23: Number of U-o-P bonds relevant for renewable energy issued by companies from 2013 to 2023, per country

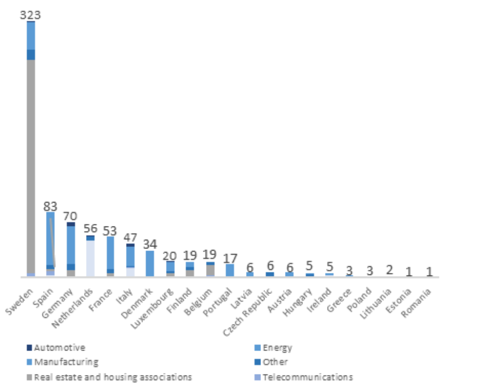
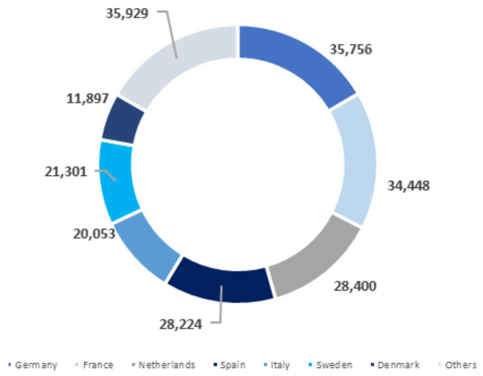


Figure 24: Aggregate volumes of UoP bonds issuances relevant for renewable energy issued by companies from 2013 to 2023 per country (In € M)



Sovereign bonds

Over the analysed time period, a total of 230 U-o-P bonds whose proceeds are totally or partially earmarked to renewable energy projects were issued by European sovereign and sub-sovereign entities, with sub-sovereigns accounting for 145 issuances and national governments accounting for the remaining 85**.** The Stockholm Regional Council was the sub-sovereign entity with the highest number of bond issuances, while the French State was the leading issuer among sovereign entities (see Figure 25)

In terms of volumes, sovereign entities (€182 billion) raised almost seven times the amount of the sub-sovereign ones (€27 billion). This trend could reflect the different – and larger – financial needs that national governments generally have compared to sub-sovereign entities, which are responsible for a narrower range of activities (see Figure 26)

On aggregate, **sovereign green bonds accounted for nearly €177 bn.** France is the Member State that issued the most, with €56 bn, followed by Germany, and Italy. This result is not surprising considering that these are also the three largest economies in the EU.

DFIs

In the analysed dataset, **368 bonds whose proceeds are totally or partially earmarked to renewable energy projects were issued by DFIs, with the EIB (136) accounting for around a third of them** (see Figure 27). The EBRD and the Nordic Investment Bank rank third and fourth, after the German NPB, KfW. This category of issuers plays an important role in financing sustainable energy projects. Typically, they issue bonds to raise funds that they can then lend out to support selected projects.

Figure 25: Number of UoP bonds issuances relevant for renewable energy issued by sovereign and sub-sovereign entities from 2013 to 2023

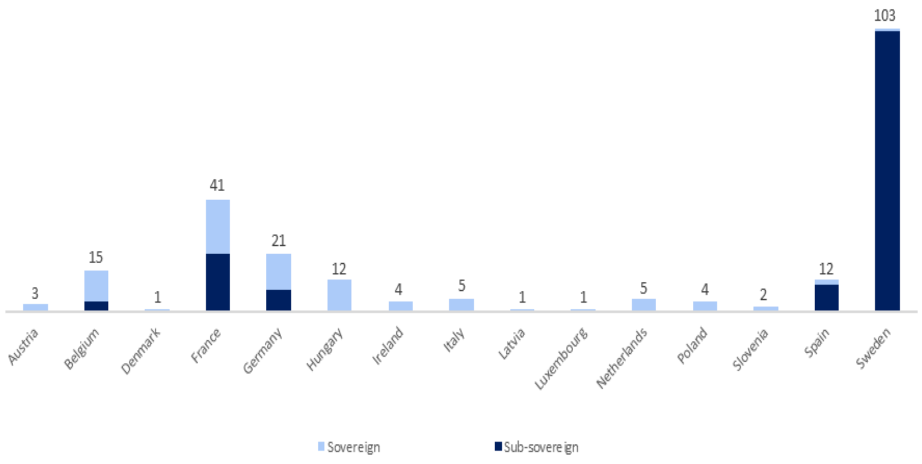


Figure 26: Aggregate volumes of UoP bonds issuances relevant for renewable energy issued by sovereign and sub-sovereign entities from 2013 to 2023 (In € M)

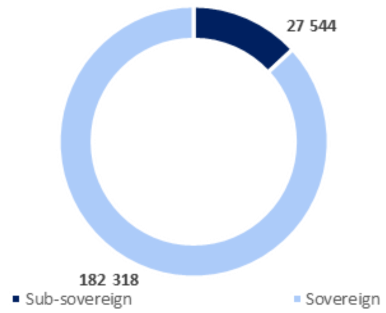
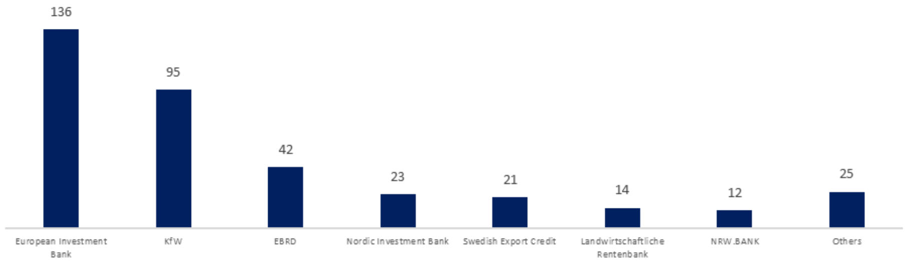


Figure 27: Number of UoP bonds issuances relevant for renewable energy issued by DFIs from 2013 to 2023



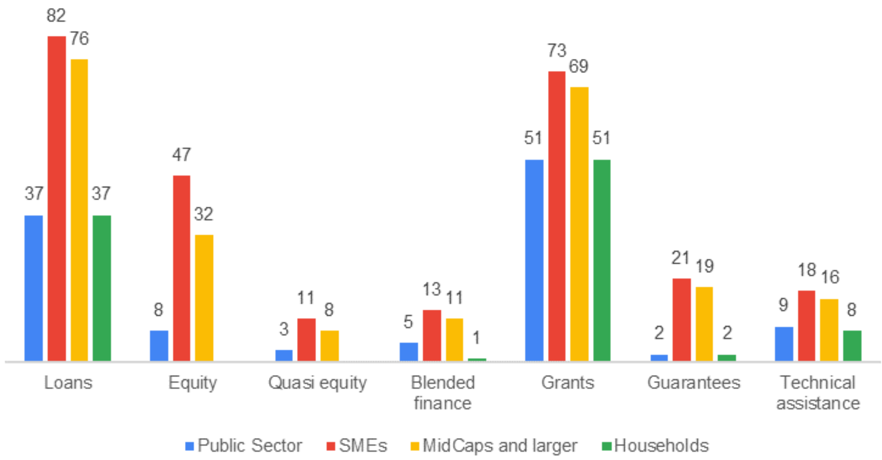
In terms of volumes of bond issuances, KfW is the largest issuer with around €57 billion worth of GBs. The bank commenced building its global portfolio in collaboration with the German Ministry for the Environment, Nature Conservation, and Nuclear Safety in 2015. The EIB comes in second place with €55 billion and the combined bond issuances of these two institutions make up over 70% of the total for this category (see Figure 28)

Figure 28. Aggregate volumes of UoP bonds issuances relevant for renewable energy issued by DFIs from 2013-2023 (IN € M)

Financing instruments by beneficiary

SMEs and larger companies are the most supported recipients by financial instruments in most EU Member States (see Figure 29). They are the most supported type of beneficiary due to their higher investment needs in general, which lead to the need for greater support. "Financing costs" was indeed indicated by both SMEs and large companies as a relevant obstacle for their green transition activities in a recent Commission report on EU SMEs[126], showing an existing need for support in the field. Croatia and Poland are the two countries which have the highest number of loan instruments towards the private sector (10) while Germany and the Czech Republic have the highest number of grants (13 and 7).

Figure 29: Number of mapped instruments per supported beneficiary by type of instrument



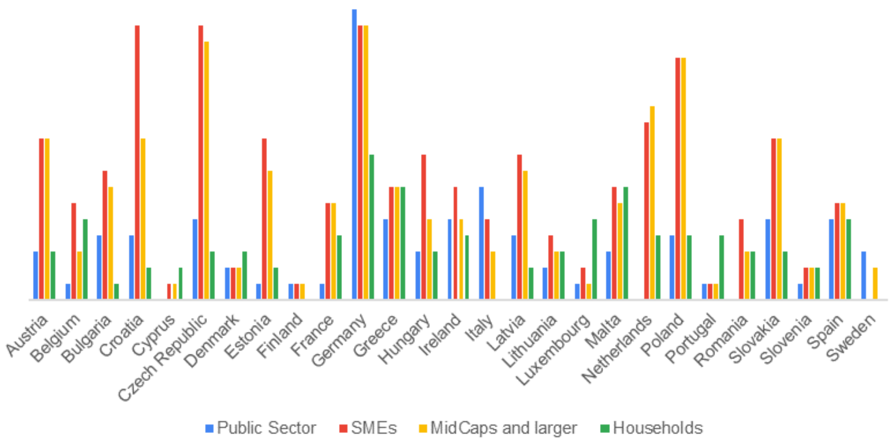
Most of the equity, quasi-equity and blended finance is directed towards SMEs and larger companies. Indeed, 87% of equity instruments target SMEs and 60% for Midcaps and larger companies. The share that is dedicated to public companies is negligible in all the EU countries. Similar results are found also for quasi-equity, where all instruments are directed towards SMEs and 73% to Midcaps and large companies.

Public-owned companies and public administrations ("public sector") are supported by about a third of the mapped instruments (see Figure 30)**.** The lower support for public sector entities could be linked to the extent such entities receive direct budget support from the state budget and their expenditures might not need to be financed through external instruments. Only 37 loans were found towards these recipients, mostly in Italy and Germany, while grant instruments for public sector are 51, mostly in Germany (16).

In this specific segment, households received a level support by mapped instruments which is comparable to that offered to public sector. This can be explained by the fact that, while pure energy-efficiency instruments - most suited for households - were excluded from the mapping, over the year many Member States have launched campaigns to incentivise cleaner residential H&C applications. Grants are the most used tool to support households, followed by loans (51 and 37 instruments, respectively).

126 European Commission (2021). Annual report on European SMEs 2021/2022. SMEs and environmental sustainability.

Figure 30 Number of mapped instruments per supported beneficiary by Country

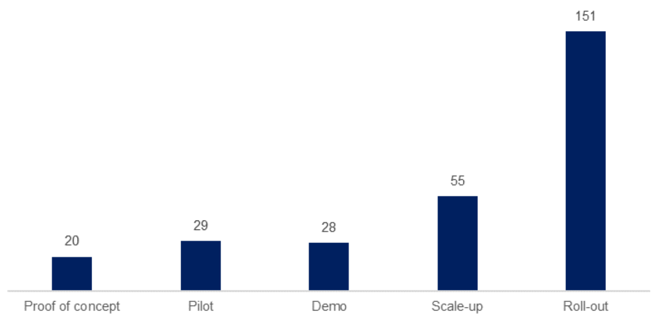


Financing instruments by targeted TRL

Financial instruments in heating and cooling target mainly projects that are mature and market-ready ("roll-out" stage) (see Figure 31)**.** Most instruments target mature technologies and roll-out stage projects/activities and the availability of instruments decreases as the maturity stage decreases towards lower TRL and early-stage technologies. Indeed, about 50% of the identified instruments target roll-out stage and 18% are aimed at scale-up stages. This trend stays the same across the different types of instruments mapped. That said, **programmes at EU level like the Innovation Fund or Horizon Europe have been put in place to provide financing for innovative but less mature technologies** that would otherwise struggle to access financing opportunities in the market. Despite not being specific to heating and cooling, these programmes can finance also such types of projects.

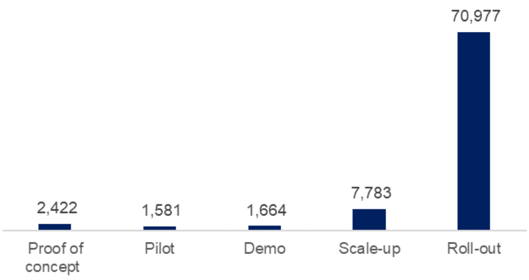
During WG discussions, it emerged how **Horizon Europe is mostly suited for pre-commercial projects.** Moreover, it has an investment pillar to support innovative solutions for cost-effective decarbonisation of buildings through energy efficiency and electrification, full-scale demonstration of heat upgrade technologies, heat-to-power conversion, and integration of renewable heat or industrial waste heat in heat-to-cold conversion systems to generate cold for industrial processes.

Figure 31: Number of instruments per maturity stage



WG Members pointed out how **low-TRL solutions in the H&C sector require long development phases that sometimes discourage investors from providing financing.** Furthermore, only mature and tested technologies are deployed, thus reducing the interest of ESCOs and municipalities in technologies of low readiness level. The Innovation Fund and Horizon Europe are possible financing solutions for innovative technologies, but continuity must be ensured to support such technologies up until the commercialization phase.

Figure 32: Volume of financing per maturity stage (€ M)



Nevertheless, **based on the available data, about €2.5 billion are available by financial instruments targeting proof of concept stage and around €1.5 billion for pilot and demo stage** (see Figure 32)**.** The trend in terms of volumes of financing understandably replicates the one of absolute number of instruments. Significantly higher volumes of financing are available for scale-up and – above all – roll-out stage projects/activities. Indeed, the latest stage alone receives a considerably larger amount than all the other stages combined, reflecting the higher amounts of financing needed to deploy a mature technology at scale. These resources mostly come from EU, national and regional budgets.

4. Assessing the relevance and effectiveness of instruments

As referred to in Section 2.3, heating and cooling projects continue to face a series of barriers limiting the provision of financing and stemming from market failures, complex permitting frameworks or underdeveloped markets for emerging technologies.

This chapter focuses on the role financial support schemes can play in addressing investment barriers affecting heating and cooling investments, and attempts to assess, based on the mapping of financial support schemes conducted, to what extent existing instruments are effective.

Section 4.1 provides more conceptual considerations and evidence from the mapping on the **capacity of different types of instruments to address barriers**. Indeed, not all barriers can be addressed through financial instruments and not all instruments address all barriers. Section 4.2 presents findings on instruments' **effectiveness** in addressing relevant barriers and reaching their objectives, drawing on evidence from the mapping and existing instrument evaluation studies.

4.1. Relevance of instruments in addressing investment barriers: theory and evidence

Theoretical considerations

This section focuses on the main types of instruments identified in the mapping linked to H&C projects.

District heating and cooling systems are usually capital intensive and require high upfront investments (CAPEX). In general, there is sufficient availability of financing in the H&C sector, but regulatory barriers are a key obstacle. Complex procedures and requirements tend to discourage or delay investment, so ease of application and implementation are a key supporting factor for the success of financial instruments. The types of financing needs in the H&C sector vary considerably depending on the project, type of operation (e.g., greenfield project/expansion of an existing network), the risk associated with it, and development stage. **Building renovation** is a way to improve energy efficiency that requires high upfront costs. The EU offers funding and support to boost renovation rates, which vary according to the type and condition of buildings. The availability of financing in the building renovation sector also depends on several factors, such as the type and condition of the buildings, the level of efficiency achieved, the price and source of energy, and the additional benefits beyond energy savings.

Investing in **high-temperature industrial processes** is a way to improve industry and the environment in the EU, using renewable hydrogen, for instance. These technologies have high upfront costs, but also many benefits. The EU offers funding and support to innovate and transform the industrial sector.

A conceptual analysis of the relevance of the instruments for addressing different barriers to investment is presented, based on the way they function and their effects on the project's bankability. This framework will then be used in sub-section 4.2 to analyse the findings from the mapping.

Loans

A loan is an agreement which obliges the lender to make available to the borrower an agreed sum of money for an agreed period of time and under which the borrower is obliged to repay that amount within the agreed time.

In case of a loan provided or guaranteed by a public authority, directly or indirectly, it can help addressing a shortage of finance available where commercial banks are unwilling to lend on acceptable terms to the borrower. Nonetheless, commercial banks can also provide loans at better conditions than normal market ones as part of their lending strategy without public support (following the market interest rate). In the case, for instance, of a guaranteed loan, the bank usually shares the risks with a public authority, which functions as guarantor and financer, and allows the bank to take a greater degree of risk exposure and provide higher amounts of financing than it would be able to do in normal conditions. In the second case, the public authority directly provides the loan and acts as financial institution. In the case of a public authority, the repayments of the loan allow the so-called revolving effect, that is the situation where the flows of money coming from the repayment of the loan is invested in another loan.

Loans play an important role in the European economy, constituting on average over 50% of the external finance of European companies. Bank loans, public subsidies and tax benefits are the basic and most spread types of tools. On most occasions, they are combined to finance different stages of the same project, especially in the case of long and complex investments. Loans are mostly provided by market-oriented public institutions such as NPBs or the EIB Group, but some products coming from private banks and funds are also present. They are mainly targeted to public sector institutions and households. Loans are the prevalent instrument of financing for both SMEs and larger companies.

While the mapping exercise did not distinguish among the different types of loans, mainly for a reason of feasibility[127], it is nonetheless useful to understand how different types of loans can help addressing investment barriers. The following paragraphs provide a description of the most relevant types of loans and the type of financing needs they address.

- **Bridge loans** are short-term instruments which are used by an individual or a company until they are able to secure permanent (long-term) financing or pay an existing obligation. Bridge loans fill the gap between two phases of a project, such as the "ready to build" phase and the moment when the project is ready for connection to the grid. Another example of bridge financing involves covering the financing needs that arise since a project obtains a grant until the moment the grant is disbursed. Such instrument allows the borrower to meet current expenditure or investment obligations by providing immediate cash flow.
- **Long-term loans** are a basic tool used for financing investments, suitable for improving the financing conditions for mature technologies with good access to commercial financing.
- **Subordinated loans** can be a powerful instrument for less established technologies with limited access to commercial lenders or for projects exposed to market risk. Such instrument is typically offered by specialised institutions rather than commercial banks, which normally prefer to take the role of senior lenders. Subordinated loans rank below more senior debt with respect to timing of repayments or claims on assets. They can therefore crowd in other senior lenders and incentivise them to lower their risk premium or collateral requirements by mitigating their risk exposure to a project. Additionally, it

[127] Feasibility considerations included a) consistency of available information across loan instruments (most loan descriptions did not provide information on loans' subordination features); and b) consistency of available information across other instruments (most guarantee, equity and grant schemes did not provide detailed information as to their type).

can leverage the investor's equity or fill the gap between the required equity for a new project and the investor's own funds.

- **Loans (individual or loan portfolios)** that facilitate the aggregation of small projects are relevant for improving access to finance for small investments. This is due to all the administrative and due diligence processes that must be performed before financing is provided, which in the case of smaller projects might not be worth the effort, as the revenues from the interest rates would be relatively small. There are two main levels at which loans can enable small-project aggregation:
    i. At the individual loan level by facilitating the presentation of small interventions and different technologies under the same loan application.
    ii. At portfolio level, where loan portfolios of similar small projects can enable larger commercial banks and providers of climate finance such as EIB to participate in the financing with larger tickets. Aggregation of small projects into larger portfolios can similarly be exploited by other financial instruments such as guarantees and equity schemes to improve the accessibility of small projects to larger private investors.

Guarantees

A guarantee is a written commitment to assume the responsibility for all or part of a third party's debt, usually a commercial bank's, if an event such as a loan default occurs. The guarantor disburses resources only if the guaranteed fails to comply with its commitments.

Guarantees provided to financial intermediaries and covering mainly default risks on underlying loans or equity are useful for increasing the provision of financing for **medium-to-high TRL projects**. Such guarantees are suited for market contexts where financing is sufficiently available, but where it is provided with too strict conditions due to **high perceived risks**, such as in the case of **young or non-investment grade companies** with inadequate collateral. For **more mature technologies**, a partial coverage may suffice in unlocking financing. Depending on the characteristics of the guarantee, it can also provide capital relief for financial intermediaries, enabling higher exposures towards capital-consuming sectors or riskier client segments for which banks may be subject to exposure limits[128]. Guarantees with high coverage rates and covering off-taker and construction risks in addition to default risks can be effective for **promoting low-TRL technologies**. Less mature technologies with a high level of innovation also face more pronounced risks across their supply chains (e.g., availability of manufacturers to supply key components, experienced construction, operation and maintenance companies to operate the technology). As such, guarantees with high coverage rates and offering protection against a wide set of risks can be a necessary tool to unlock bank financing for innovative and less mature solutions, as commercial banks might otherwise not invest due to uncertainty in the performance of the technology, long investment horizons, or underdeveloped supply chains. For final beneficiaries (i.e., companies and households), guarantees take the form of a loan, as the guarantee is always provided to a financial intermediary, a bank or a fund, for instance, which then provides financing at better conditions.

The nature and structure of guarantees can also differ depending on barriers or investment specificities they aim to address. In addition to different coverage rates, guarantees differ according to the **nature of the guarantor** (public or private), **how many investments** are covered (individual or portfolio) and **how the risks are shared** between the guarantor and the

[128] See example of MIDIS – Natwest capital relief transaction in the UK enabling increased lending to the sustainable energy sector

beneficiary of the guarantee (pari passu or other arrangement). The paragraphs below provide some further considerations on these elements.

Guarantees provided by public sector entities, such as sovereign or regional governments, can be effective in supporting private borrowers raise sufficient debt for new investments. Public institutions can increase the provision of finance at better conditions in the economy without bearing upfront costs (as the disbursement takes place only in the case of non-repayment of the loan). Guarantees are particularly suited for market conditions where financing is sufficiently available, but it is provided with too strict conditions due to the high perceived risks. In this case, the role of the public sector is not to provide additional financing, but to reduce the potential risk exposure of commercial financing institutions. By issuing a guarantee rather than contributing directly to the financing of an investment, the public sector entity avoids a **crowding-out effect**. In addition, for the public sector budget, a guarantee constitutes an **off-balance sheet instrument** which is not considered as public sector debt as long as the revenues of the underlying project make it economically viable. This makes guarantees an **efficient tool** for governments to improve access to finance and financing conditions in target energy sectors, without the public authority having to disburse any public resources unless there is a case of default.

Guarantees can also be **individual or portfolio instruments**, depending on whether the guarantee covers one specific investment/project, usually a large-scale one, or multiple, often smaller ones. Portfolio guarantees are also functional at **aggregating smaller-scale projects** that would otherwise struggle to access finance due to the small amount of financing they need. In the case of portfolio guarantees, a further differentiation can be found in how the risk is split in case of default of one or more investments in the portfolio. In the case of **pari passu guarantees**, the risk is shared between the guarantor and the intermediary on all investments based on a pre-determined allocation (e.g., 50%-50% or 60%-40%). In case of **first-loss portfolio guarantees**, the guarantor covers the risks of a first tranche of defaults within the portfolio based on a pre-determined covered rate (e.g., 80% coverage on 20% of the portfolio). First-loss portfolio guarantees are useful when developing **portfolios of projects with different levels of maturity**, as the intermediary will be more protected if less mature and riskier investments default (as they are more likely to default first).

Focusing on the H&C sector, in most of the cases, guarantees are provided by the public sector, especially through facilities which come from either the EIB Group or other EU funds. Usually, guarantees target multiple or all segments of the energy value chain, and not only H&C. The identified areas of improvement of guarantee schemes concern the **lack of visibility** of the available schemes, the **presence of funding gaps** where H&C projects are not eligible, the **uncertainty about the long-term availability of schemes**, as well as the **potential limitations of their eligibilities and targets** since they often focus on mature technologies rather than innovative ones. Guarantee schemes in H&C should also target the demand side, such as distribution of heat, and not only the supply side. **Guarantees should be combined with different types of financial and non-financial support schemes to support investments in H&C.** For DHC, for instance, a combination with grants and regulatory measures, such as planning and obligation (or suasion) to connection, could support investors. Unfunded guarantees combined with subordinated loans could be a fitting instrument in case of a project presenting volatility in revenues or cash- flows. Finally, start-up grants and first loss guarantee schemes could be fitting for a case of uncertainty on completion of the production (geothermal).

Equity and quasi-equity

An equity investment is the provision of capital to a company, invested directly or indirectly in return for total or partial ownership of that firm and where the equity investor may assume some management control of the firm and may share the firm's profits. In the case of equity, the financial return depends on the growth and profitability of the company and is earnt through dividends and/or the sale of the shares to another investor.

Due to its nature, equity finance exposes the investor to a higher degree of risk, but also to potentially higher returns. It is particularly suited for providing initial capital for young innovative companies and new technologies, looking for additional financing but not yet suited to apply for debt, as well as for mature technologies to close financing gaps.

Quasi-equity is a type of financing that ranks between equity and debt, having a higher risk than senior debt and a lower risk than common equity. Quasi-equity investments can be structured as debt, typically unsecured and subordinated and in some cases convertible into equity, or as preferred equity.

There are various forms of equity financing, each with its own unique features, risk level and return potential. Equity is usually provided either directly or indirectly. In the first case, the financial institution makes a **direct equity participation** in the company (potentially through an SPV), thus directly acquiring a certain number of share and, therefore, of ownership. This direct participation can take the form of smaller-sized investments from venture capital or angel investors for start-ups and younger energy companies, or of larger PE investments from investment funds or corporates for utility-scale companies. Alternatively, the investment can be done **indirectly through financial intermediaries**. The financial institution invests in another fund (investment fund, fund-of-funds, etc.), which will in turn invest in one or more companies based on its predetermined investment strategy. In the first case, that of direct investment, it is up to the financial institution to undertake all due diligence and screening processes. In the second case, it is up to the investment fund to do so, and the financial institution only needs to select the fund(s) the most aligned with its policy and investment objectives. Indirect equity schemes also allow **institutional investors** (e.g., pension funds, insurances, national and international financial institutions, etc.) to play a role in energy financing without the need to develop tailored expertise and know-how in it.

Private equity tends be the most suitable instrument for H&C projects, since they are ideal for mid-mature stage portfolios. Besides, fund-of-funds can be useful since they enhance further diversification of risks. Equity is more suited for large and complex projects, meaning that smaller ones will struggle to access this type of finance. To address this barrier, municipalities and/or ESCOs could function as aggregators for smaller projects.

According to WG members, the ideal features and characteristics of equity schemes for H&C would be an investment of €30 to 50 M, a multiplier effect ranged from 3 to 4, and a combination with technical assistance.

The following barriers and some corresponding suggestions have been identified in relation with H&C:

- The mismatch between supply and demand of financing is a key challenge for the H&C sector. WG discussions indicated that longer-term business plans and the aggregation of several projects to reach an adequate investment size can be ways of bridging the gap.
- H&C projects could also be made more attractive for equity and quasi-equity financing via a thorough and widely recognised technical/commercial due diligence process.
- Equity schemes, on the other hand, would be more attractive with simpler procedures, long-term visibility and stability of the legal framework.
- EIB and EIF equity schemes are generally highly regarded and well appreciated, also because EIB solutions can be very creative and innovative. However, greater flexibility in the decision-making process would help them be even more effective. The challenge comes when dealing with process or legal structuring.

Grants

Grants are direct financial contributions provided to third-party beneficiaries (i.e., companies and households) conditionally or unconditionally. This contribution does not need to be paid back and is usually aimed at covering part of the upfront costs (CAPEX) or of the operating costs (OPEX) of a project. Grants can also be used to cover the costs of technical assistance to companies to conduct energy audits, develop bankable projects, etc.

Because of their non-repayable nature, grants are particularly suited to support projects in the very early stages of development, where market dynamics are hardly applicable, and to incentivise beneficiaries to pursue projects that are less attractive from a financial point of view, but that are needed to achieve policy goals.

Grants can be relevant in addressing a number of investment barriers, depending on the types of beneficiaries targeted and cost components covered. Grants can be used to internalize externalities, which otherwise would not have been considered in investment decisions. These externalities can be of negative (e.g., climate externality) as well as positive (e.g., positive spill over effects) nature.

There are different types of grants that public authorities use to support investments. The following paragraphs provide a description of some the most common types of support and the financing needs they address.

- **Investment/capital grants** are usually provided to cover development costs, finance viability gaps and reduce the ultimate financing costs to increase projects' competitiveness. They are well suited to address **restrictions in access to finance affecting less established technologies**, where private investors may be reluctant to invest due to a high degree of novelty and technology risks, product-market fit or high investment costs. In addition, private investors may not consider the **positive spill over effects** resulting from research, development and innovation in new energy technologies, leading to sub-optimal investment outcomes. In this case, grants can provide a necessary financial incentive for the development and commercialization of low TRL technologies until they are able to access commercial financing.
- **Capital rebates** can be used to incentivise promoters to complete projects **in a timely fashion** or to a **certain performance level**. Rebates are lump-sum payments that cover a portion of a project's development cost and are paid to promoters **upon project completion**. Similar to capital grants, rebates lower the amount of project costs that need to be financed by private investors, thus improving the economic incentives for target energy investments.
- **Interest rate or guarantee fee subsidies** facilitate access of individuals and companies to existing lending or guarantee schemes. By improving the financing conditions of underlying financial products (loans, guarantees), such subsidies strengthen individuals' and companies' incentives for obtaining commercial financing for energy investments. This type of support can be particularly relevant for **smaller companies** (in addition to individuals), who may lack the ability or opportunity to negotiate bilaterally with banks the financing conditions of new loans they are interested in contracting.

Indirectly, grants can also address **insufficient planning and preparation capacity** affecting promoters who lack the experience in H&C projects. This can take the form of **technical support grants** to cover part of the project preparation costs, such as energy audits conducted by externals or other studies to be conducted towards FID, but also have a great benefit in OPEX financing for SPV.

Bonds

Bonds are a fixed-income instrument that represents a loan made by an investor to a borrower. In return for the loan, the bond issuer will pay interest to the bondholder at fixed intervals until the bond matures and the money is paid back. Bonds can be issued by companies or by public entities, and they are relevant for amplifying the sources of medium to long-term capital available to the clean energy sector. Two types of bonds are discussed here:

- **Green Bond** refers to any type of bond instrument where the proceeds are exclusively used to finance or re-finance, in part or in full, new and/or existing projects with environmental benefits.
- **Sustainability-linked bonds (SLBs)** are a type of financial instrument that is designed to incentivise issuers to achieve predetermined sustainability targets, such as reducing greenhouse gas emissions or improving social outcomes within their company, organisation, or country.

Green bonds can be issued by sovereigns, NPBs, commercial banks or corporates directly. By earmarking their proceeds towards sustainable projects, green bonds can serve as an important bridge between providers of capital, such as institutional investors, and clean energy production projects. Besides, bonds enable upfront CAPEX costs to be sustained in cases where no subsidy is available, or where subsidies are available only as reimbursed expenses (meaning that the project promoter still needs to bear the upfront cost and gets the reimbursement only afterwards). Public utilities can raise financing from bonds, and public administrations can use them both to collect funding for improving energy conditions of their own buildings or to implement facilities for citizens to be more energy efficient. For portfolios of projects or larger projects, bonds are also a viable option, in order for the fixed transaction costs to be reduced. Due to their usually longer maturity, they can result to be cheaper than loans.

In the context of renewable heating, both green bonds and sustainability-linked bonds are relevant: green bonds can be used to finance projects such as the installation of renewable heating systems or the development of new renewable heating technologies, while SLBs can be used to encourage issuers to improve their sustainability performance in renewable heating.

Green bonds are also relevant as a mechanism to raise capital for financing schemes. For instance, a Bank may emit a green bond to finance a scheme for small scale loans for individual geothermal heat pumps in a given area. Similar practices have already taken place for energy efficiency financing. This type of financing is especially relevant for commercially mature projects, and rather for medium to big sized developers. However, green bonds can finance H&C projects of all sizes, for instance with the emission of small business or households loans for renewable H&C investments. Green bonds are also relevant schemes for utilities, large scale investors for financing a single large project or for a portfolio.

Overall, the market trends for green and sustainability-linked bonds issuances in renewable heating are expected to continue to grow as investors increasingly prioritize sustainable investment options.

Blended finance

Blended finance is the combination of finance from public and private resources to implement a certain project jointly by the public and private sector. They are used to achieve public policy objectives that, in the existing market conditions, cannot be achieved through pure market dynamics and/or legislation.

Such instruments can help **mobilize commercial investment** towards clean energy projects, whilst limiting the use of scarce public resources only to the extent needed to crowd-in enough private finance. Blended finance interventions benefit from the possibility to be tailored to particular sectors, technologies and barriers (e.g., equity co-investment facilities providing growth finance to SMEs), making them a versatile tool to mobilise commercial financing towards priority sectors and types of beneficiaries.

A blended finance instrument is typically developed by a public entity together with one or more private entities, where all entities involved pool their resources. Contrary to more standard financial instruments in which public resources crowd-in private ones after the launch of the instrument, in blended finance schemes **private and public resources are combined since the creation of the instrument**.

The most common types of blended finance are **concessional capital** and **credit enhancement** (risk insurance). Blended finance is often also combined with technical assistance grants, to provide capacity building and knowledge-sharing to the beneficiary, to strengthen its commercial viability and support in the transaction preparation.

The main investment barriers for private investors addressed by blended finance are high perceived and real risk, and poor returns for the risk relative to comparable investments. Blended finance aims at creating investable opportunities in developing market sectors, as well as in sectors with under optimal returns to attract sufficient private investments.

Technical Assistance

Technical assistance refers to different types of services provided to final beneficiaries and/or financial intermediaries to improve their capacities/skills to, for instance, perform business modelling, financial planning, risk assessment, report, etc.

Technical assistance is relevant for improving the planning and preparation capacity of project promoters and their ability to benefit from financial instruments. Technical assistance schemes are often primarily paired with loans or grants to SMEs, Midcaps or public sector entities and referred mostly to environmental impact assessments, feasibility studies or support on regulatory and policy matters.

TA can be developed to help project promoters preparing a solid business and financial plan that is ready to be submitted to investors and financial institutions, and thus **improve the investment readiness** of projects and **their ability to access external financing options**. Combining technical assistance with instruments such as loans or grants can therefore facilitate the implementation and uptake of such instruments to support well-defined and more mature project proposals.

Evidence from the mapping of instruments at Member State level

The mapping collected available evidence on the relevance of financial instruments for addressing investment barriers currently affecting Heating and Cooling projects[129]. For most instruments mapped, the instrument descriptions and guidelines would typically not refer to the investment barriers targeted. Therefore, for each instrument, its relevance for addressing barriers to investment was established/assessed based on the following sources of information:

- **Instrument type**: The instrument's type (e.g., loan, equity, guarantee) and typical functioning mechanism were taken into account to identify the investment barriers that are most likely to be targeted. To reduce the risk of self-confirmation bias based on the theory of instruments' relevance in addressing barriers, inferences made from the

[129] The set of barriers considered are those identified by WG participants as most relevant and presented in Section 2.3

instrument type were contrasted with other sources of information (see following points).

- **General description**: Most instruments in the mapping came with a general description summarising the instrument's main features and eligibilities. Although usually limited in detail, some descriptions were able to provide insight on the investment barriers targeted by the respective schemes. This was mostly in the case of descriptions that explicitly referred to instruments' favourable financing terms, reduced collateral requirements or subordinated position, from which it was possible to infer the instrument's relevance for improving the financing conditions of underlying investments.
- **Instrument-specific characteristics**: In the case of instruments accompanied by more detailed guidelines, their relevance for addressing investment barriers was inferred from instrument-specific features that signalled relevance towards particular barriers. Some examples of such characteristics include:
  - **Targeted innovation level**: For instruments targeting mainly newer technologies and innovative projects it was generally possible to infer instruments' relevance for addressing restrictions in availability of finance, which typically affect less-established technologies.
  - **Eligible investments and project costs**: For instruments considering project and document preparation costs as eligible expenses covered by the instrument it was generally possible to infer instruments' relevance for addressing limitations in promoters' planning and preparation capacity.

However, some methodological caveats should be taken into consideration when reading the results presented below. The information presented in the graphs below should be interpreted as general trends rather than exact matches between instruments and specific barriers.

This is because of two main reasons: (i) **Most instruments mapped for H&C do not only target H&C** projects, so the barriers identified as relevant may also be in relation to other segments of the energy value chain. (ii) Most **barriers are correlated**, meaning that they are caused by intertwined conditions that might also lead to other barriers. For instance, a new, innovative, and not-yet-tested technology might face heavy administrative requirements due to such technology not yet being regulated. At the same time, it might also be subject to worse financing conditions compared to other more mature technologies due to its perceived technology or market risk. Furthermore, the company might struggle to hire workforce with the right qualifications to operate such a new technology. These four barriers all stem from the fact that the project is based on a new and innovative technology but are counted as different as they affect different aspects of the project. This of course poses challenges in the identification of barriers addressed by different instruments, as, from a theoretical perspective, addressing one barrier might also, indirectly and partially, address other barriers (e.g., reducing the technology risk exposure of an investor might increase the overall availability of financing, as the investor has to bear less risk and can thus invest more if willing to do so).

Financial instruments for H&C investments target mostly investment barriers related to availability of finance, financing conditions and market risk of energy investments. The results of the mapping confirmed the expected relevance of instruments for the first two types of barriers, across all types of instruments considered (see Figure 33 below). Around 90% of mapped instruments across the main instrument categories (loans, grants, equities and guarantees) address restrictions in the availability of finance and approximately 50% address restrictions in financing conditions.

Figure 33: Number of times investment barriers were identified as being "addressed" or "partially addressed" by the mapped instruments - by type of barrier.

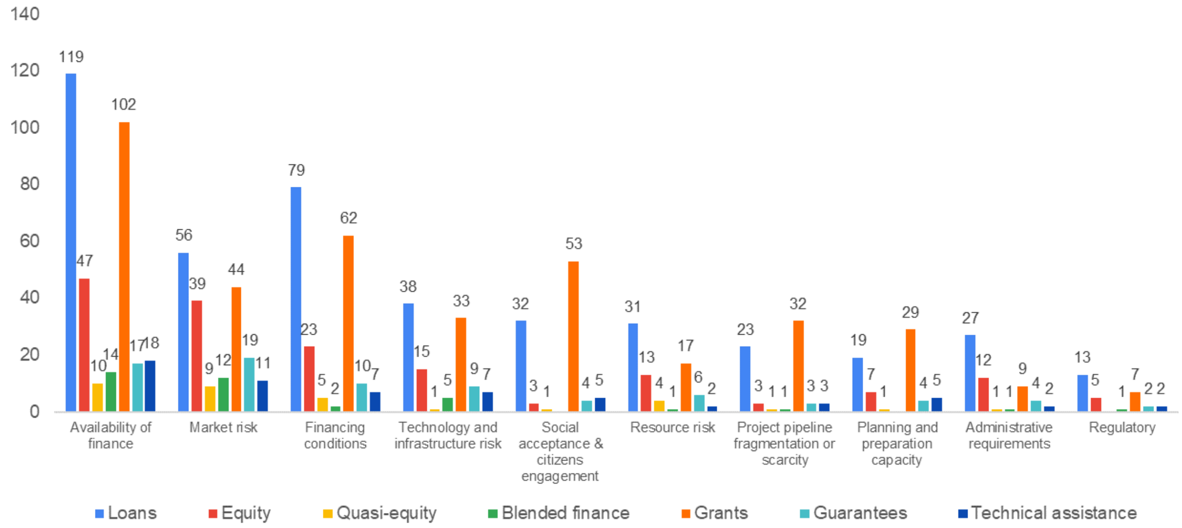


Table 3: Percentage of instruments mapped and identified as "addressing" or "partially addressing" particular barriers (out of the total number of those types of instruments mapped for H&C)

	Availability of finance	Market risk	Financing conditions	Technology and infrastructure risk	Social acceptance & citizen engagement	Resource risk	Project pipeline	Planning and preparation capacity	Administrative requirements	Regulatory risk
Loans	88%	41%	59%	28%	24%	23%	17%	14%	20%	10%
Equity	87%	72%	43%	28%	6%	24%	6%	13%	22%	9%
Quasi-equity	91%	82%	45%	9%	9%	36%	9%	9%	9%	0%
Blended finance	93%	80%	13%	33%	0%	7%	7%	0%	7%	7%
Grants	93%	40%	56%	30%	48%	15%	29%	26%	8%	6%
Guarantees	65%	73%	38%	35%	15%	23%	12%	15%	15%	8%
Technical assistance	86%	52%	33%	33%	24%	10%	14%	24%	10%	10%

Market risk is also identified as one of the most relevant barriers in the mapping[130] (see Table 3). In the case of **subsidised loans and grants**, their relevance in addressing market

130 Market risk is typically thought of with utility scale renewables in mind, where FiTs and PPAs (rather than financial support schemes) are effective in reducing this type of risk. As the mapping did not consider PPAs, results obtained can be reconciled if one considers how market risk affects target beneficiaries in our sample, primarily SMEs, public entities and households. For these beneficiaries, market risk can manifest in uncertain future electricity or heating prices making it difficult to plan for RE/DHC investments involving self-consumption. Fluctuating energy prices reduce the incentive to install RE equipment, as the benefit

risk stems from the financial incentive these instruments provide to beneficiaries for **bearing the upfront cost** that will translate in **future energy savings** (e.g., investments in district heating or residential or industrial efficient heat pumps). The mapping provides some evidence in favour of this hypothesis, particularly for equity, quasi-equity, and blended finance. In relation to the mapped **equity** instruments addressing market risk, these could reflect the role of **public-supported equity funds in de-risking new technologies or large DH projects**. While investors may have some visibility on the future revenue stream of new technologies, unstable energy prices and unclear business models may still pose a risk to future revenues and raise the risk profile of investments. Publicly supported schemes, such as EIB's InnovFin Energy Demonstration projects[131], could therefore be necessary to crowd in private investors and mobilise equity financing for innovative projects in the field of renewable H&C technologies.

Technology and infrastructure risk was mostly being targeted by guarantees, blended finance and technical assistance schemes, with c. 34% of such mapped instruments addressing this barrier. The mapping identified a limited number of instruments that were identified as targeting technology and infrastructure risks, with the exception of loans and grants (38 and 33 instruments mapped, respectively, targeting also technology and infrastructure risk).

this would bring is uncertain and periods of low energy prices might not make it worth from a financial perspective. Similarly, for utility companies, unstable energy prices mean unstable revenues and without certainty on future prices, banks and investors might be reluctant to provide financing to utilities.

[131] European Investment Bank. InnovFin Energy Demo Projects. https://www.eib.org/en/products/mandates-partnerships/innovfin/products/energy-demo-projects.htm

Box 10: Infrastructure barrier in DHC

Example of infrastructure barrier: Transition to low temperature district heating (4th generation)

District heating has a high decarbonisation potential and can be used to integrate large shares of renewable energy and excess heat into the heating sector. 4th generation district heating systems are regulated at lower temperatures (30-70 C) compared to traditional systems (80-115 C). This provides significant benefits in terms of efficiency of the distribution through heat losses and improves the potential for integrating new sources of heat into the system (e.g., heat pumps, excess heat from industries, etc.).

However, new generation district heating systems poses technical challenges to the existing infrastructure, particularly in terms of pipe capacity within the distribution network, heat exchanger, and heat distribution within buildings. For instance, low temperatures mean lower temperature difference between supply and return flow. This in turn results in either reduced transport capacity of the pipes in the network if the flow rate is unchanged, or higher pressure drop if the flow rate is increased to compensate the effect of a lower temperature difference[132]. Furthermore, while floor heating and ventilation heating require little adaptations to work with low temperature district heating, radiators can require a replacement of the substation heat exchangers, and more expensive intervention might be needed if the radiator cannot create the required or sufficient amount of heat due to the low temperatures provided by the system.

These challenges affect particularly existing buildings and districts, as the upgrade of the different systems requires tailored cost-efficiency evaluations, and the benefits of it can be unevenly distributed among the parties (customers, local utilities, etc.).

Social acceptance and citizen engagement is mostly targeted through grants and, to a lesser extent, through loans, but in general financial instruments are not the most relevant means to address such barriers. The identified examples were mainly in relation to schemes for companies and households promoting building upgrades and renewable energy/new heat pumps installations. Particularly for grants, this finding is in line with theoretical predictions that they can improve citizen engagement for investments outside the household/company's core needs. This is the case, for instance, when citizens are potentially interested in installing new heat pumps, boilers, cooling systems or solar panels in their households or companies, but such an investment is not a priority if there are not sufficiently strong economic incentives. If they need to bear the full upfront costs on their own, citizens might refrain from investing. However, if part of the cost is either directly covered or reimbursed by a subsidy, then they might opt to undertake the investment, thus contributing to the achievement of EU's climate objectives and goal.

As expected, financial instruments were not found particularly relevant for addressing regulatory barriers or those related to supply of labour. Subsidies or private sector investments would not do much to address the shortage of skilled and qualified labour. This barrier would be best addressed through a wider upskilling programme that includes relevant courses. Similarly, regulatory barriers cannot effectively or efficiently be addressed through financial schemes, as they require regulatory and/or legislative changes to the framework governing that sector and can also be influenced by political decisions. Working Group members noted that the huge expansion of renewable energy needed to meet 2030 targets will only be possible if Europe has the right **energy market design** in place, which should

[132] Rama, M.; Sipila, K. (2017). Transition to low temperature district heating. *Energy Procedia* 116(2017): 58-68.

seek **to avoid market distortions** as governments take measures to support vulnerable consumers in the current energy crisis. The proposed Electricity Market Design reform[133] was overall positively welcomed by WG Members, who nonetheless stated that the proposal still needs to undergo approval from the European Parliament and Council, and is thus still subject to possible changes.

A similar situation applies to the barriers related to administrative requirements and resource risks, which are caused by elements outside the financial market landscape, despite affecting it. Although these barriers found more relevance in the mapping compared to regulatory and labour-related risks, financial instruments are still an insufficient tool to tackle such barriers effectively. Responding to risks in the supply of key raw materials needed for the construction of DHC projects will require a more holistic policy response, where better access to finance for strategic supply chain projects is likely to be one of several measures needed to build more resilient supply chains[134].

The findings indicate there is further need for (i) instruments that at design level facilitate the aggregation of smaller projects and (ii) instruments combining technical assistance support with financial support. Barriers related to **project pipeline fragmentation or scarcity**, and to **planning and preparation capacity** were identified in a minority of cases as being at least partially addressed by the mapped instruments. Recent studies have also highlighted the need for aggregation of small-scale RE projects, including residential and industrial heat pump installations[135], and for enhanced technical assistance to local authorities, particularly when it comes to understanding and using available resources for decarbonising their building stock, and for planning and managing district heating projects[136]. The fragmentation and small size of projects is something that could be better targeted through new or revised financial support schemes. This would be addressed not through the provision of financing per se, but rather through instruments' design and capacity to aggregate small projects under common eligibilities, allowing private investors to co-finance such schemes with meaningful ticket sizes. Issues related to planning and preparation could be addressed through additional technical assistance programmes coupled with existing financial support schemes.

4.2. Evidence on the effectiveness of financial instruments – Findings from the mapping

Effectiveness of a financial support scheme can be defined as the instrument's capacity to achieve its objectives and targets, intended as addressing barriers and market failures, making a project bankable, mobilising additional financing, and contributing to the achievement of energy and climate objectives.

However, this type of assessment can be done only once the scheme has been fully deployed and when the projects that have received financing are completed. Since the mapping exercise covered only ongoing and recently closed financial schemes, there was so far only in very few cases an available analysis on instruments' effectiveness. Quantitative and qualitative metrics on the deployment and impacts of the schemes are not yet available. Data on resources disbursed, financing crowded-in, KJ/GJ of renewable heat produced, GW

[133] European Commission. Electricity Market Reform for consumers and annex. https://energy.ec.europa.eu/publications/electricity-market-reform-consumers-and-annex_en

[134] Critical Raw Materials Act securing the new gas oil at the heart of our economy I Blog of Commissioner Thierry Breton

[135] Combination of financial instruments and grants, fi-compass Factsheet, May 2021

[136] Technical assistance: Local authorities needs and upcoming policy, BuildUpon, November 2021

of new capacity installed, and jobs created will likely be public only once mid-term and ex-post evaluations are conducted. This is not the case for the majority of instruments mapped.

Given these limitations in data availability, the analysis of effectiveness has been structured around the factors supporting effectiveness, that is the characteristics and features that a financial support scheme can have, and which are functional to its effectiveness. These factors were defined based on consultations with WG members and other stakeholders from different Member States.

The four main factors identified as key for effectiveness are:

1. **bigger ticket size- aggregating multiple projects to create more attractive ticket sizes for investors,**
2. **low bureaucratic requirements,**
3. **sustained long-term support,**
4. **easy application process available throughout the year**

Based on the findings from the mapping, it was possible to assess to what extent some of these factors are present in existing financial support schemes and provide examples of effectiveness in addressing barriers to investment and in mobilising additional financing.

Enabling factors for instruments' effectiveness

Bigger ticket size

The mismatch between supply and demand of financing was one of the main challenges in the availability of equity financing identified during the WG meeting. This refers to when the investments ticket size needed by H&C projects is **too small to be attractive** for many institutional investors. WG members suggested to **aggregate multiple projects** to reach an adequate investment size. However, aggregation remains a challenge since each case must be assessed individually despite a standardized implementation.

Besides, the construction of new networks represents a large infrastructure investment which does not generate returns in the short-term and therefore is not considered an asset from its conception. **Private investors are more incentivised to invest when projects have a certain size**. Because of this, the **aggregation of multiple smaller projects** (such as individual heat pumps, or DHC for few residential units) is preferred, so as to de-risk their portfolios. In this context, public support becomes essential to both aggregate projects, and, more importantly, to provide reassurance in terms of long-term visibility and market stability.

This is even true for certain types of financing. For example, equity and green bonds are more suited for large and complex projects, meaning that smaller ones will struggle to access this type of finance. To address this barrier, municipalities and/or ESCOs could function as aggregators for smaller projects.

However, **aggregation remains an issue for small institutions**. The actor in charge of the aggregation if rather private capital, thanks to their entrepreneur activity, commercial "nimbleness" and ability to take risk. Indeed, this can be more challenging for the public sector which rather comes into play at a later stage when the network is built out.

Different types of financing should be combined in larger projects. However, it is important to clearly define what is funded by what, as overlapping should be avoided, and also to optimise the use of public resources. This responsibility is equally split between the public sector, when defining financial support schemes, and the private sector, when developing business and financial plans.

Low bureaucratic requirements

Complex procedures and requirements discourage or delay investments in the H&C sector. **The complexity of** application and implementation processes is a key issue identified by participants and it should characterise the next generation of financial instruments.

For instance, **a technology neutral and sector agnostic instrument profile** was generally pointed as useful to support the effectiveness of instruments, since it helps **simplifying a financial instrument**. It also helps to **broaden its scope and eligibilities for underlying projects and final recipients**. As such, simpler specifications can support instrument deployment in broad sectors like energy investments. WG Members agreed that a broad and flexible scope, understood as an instrument's capacity to finance different types of technologies, sectors, projects, and projects sizes are important for the instrument's effectiveness.

Long-term support

Long-term planning was mentioned as a key enabling factor for the mobilisation of private capital for all DHC projects as it would provide **long term visibility and predictability**. Participants reflected on the need for a wider H&C mapping at national level in order to have a greater overall understanding of the potential available structures in need of investment. Furthermore, the process for ideating, developing and structuring a project is long and complex, and requires **project promoters to have visibility on the long-term conditions on which the project will be implemented**, so as to adequately plan their business and financial models. Even smaller changes in application requirements, eligibility criteria, or instrument functioning can derail the project preparation.

Uncertainty around the **long-term availability** of financial instruments is a major barrier for investors, as they face uncertainty regarding the availability of co-financing schemes and might not remain for the whole lifecycle of the project. **The stability of the instrument over long-term, intended as both the regular provision of financing, and the lack of unforeseen changes** occurring during the instrument's lifetime helps create trust among investors, thus incentivising them to invest. Sudden and unforeseen changes would negatively affect investors' trust and confidence in the instrument, reducing their engagement with the instrument.

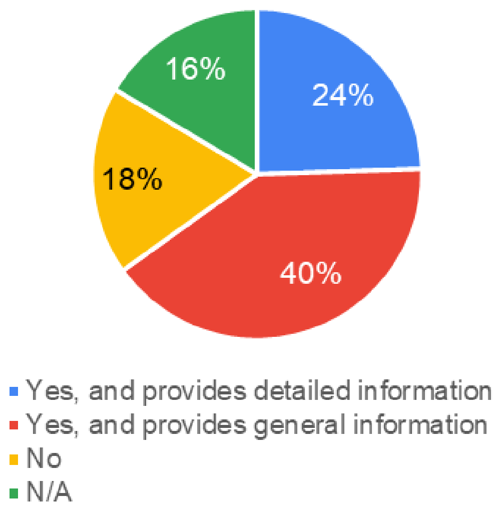
Lastly, **regulatory certainty, consistency, and predictability** was identified as essential to secure private capital in DHC projects. The WG Members largely agreed that frequent changes in regulatory frameworks have resulted in a lack of long-term visibility of revenues, creating a non-favourable environment for investors. Unbalanced and unstable regulatory frameworks can compromise investor confidence in the credibility of those frameworks leading them to deciding not to invest.

Easy, periodic, and rapid application process (Accessibility)

Discussions in the WG highlighted the key role of accessibility in an instrument's effectiveness. The availability of an application manual to support project promoters in the application process, the timing of the application, the possibility to contact the implementing authority with queries, and the average length of the application are all possible ways of ensuring that an instrument is accessible for its target group.

A potential project promoter would apply to get financing from a financial instrument only if the effort required to submit such an application is acceptable in relation to the amount of financing to be received, and the likelihood of success. For each individual

Figure 34: Shares of instruments for H&C with and without an application manual



project promoter and project there is going to be a “breakeven” point from which the amount and/or type of financing to be received is not worth the effort necessary to comply with the application requirements. Indeed, application processes with too many requirements or instruments with burdensome monitoring and reporting requirements will likely be perceived as less interesting by potential project promoters. This phenomenon is even more relevant for SMEs, start-ups, but also local public administrations and municipal companies, as they have a smaller pool of personnel, often without dedicated support staff to take care of different administrative requirements and commitments compared to larger companies. For this reason, an instrument’s effectiveness is also affected by its accessibility to all types of project promoters. In this context, an instrument’s accessibility has been assessed against four criteria: the availability of an application manual, the application periodicity, the length of the application in terms of number of pages that needs to be submitted in the application, and the possibility to contact the implementing authority to ask questions and clarifications.

Out of the 300 financial support schemes mapped as available for Heating & Cooling, two thirds of them, 194, have an application manual available to potential applicants (see Figure 34). Most of the instruments with an application manual are loans (93) and grants (72), followed by equity (38), and guarantees (22)[137]. Of these 194, 73 had an application manual with detailed information on the application process and requirements, and 121 had an application manual with more general information on the process, but without going into details on the different steps, leaving to the applicants to understand the requirements. Finally, for 104 of them no application manual was identified, either because it could not be found or because it does not exist.

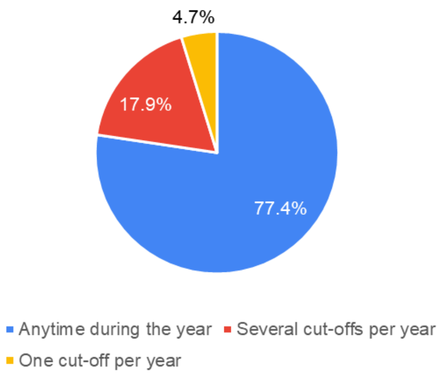
While the availability of an application manual is not a guarantee of effectiveness, it does nonetheless contribute to reducing errors in applications and helps making the instrument application process clearer and easier to follow. These characteristics were highlighted by WG Members as important for instruments to be attractive, as complex application procedures and requirements were often mentioned as a barrier to investment, particularly when it comes to the use of EU funds. The application manual may also include aspects of investor strategy, which help potential beneficiaries to understand the ambition and investment rationale and thereby establish, whether they are a fit to the investments targeted. As mentioned above, the manual does not affect the effectiveness of the instrument per se, but it rather reduces the possibilities that smaller project promoters do not receive financing because of administrative or bureaucratic mistakes committed during the application process.

The second factor analysed when it comes to accessibility is the **periodicity of the application window**. The assumption made in this case is that an instrument for which promoters can apply at any given moment in time (i.e., on a rolling basis) is more accessible compared to one that has limited cut-off windows. This is because projects might follow timelines that are not aligned with an application’s timeframes. Because of this, project promoters might not be eligible for it or might not decide to apply for it, thus negatively affecting the absorption of that instrument and, consequently, its effectiveness. For the majority of

[137] Double counting possible.

instruments for H&C (190 out of the 300) it was possible to identify the timing of the application period. For most instruments (147), applications are also possible anytime during the year. This gives greater flexibility to applicants, as they are less restricted in terms of when they can apply. For 34 instruments there are several application windows per year, but it is not possible to apply anytime, and for 9 instruments there is only one application window per year[138]. The Figure 35 includes instruments for which only one application period was/is envisaged.

Figure 35: H&C instruments by application period



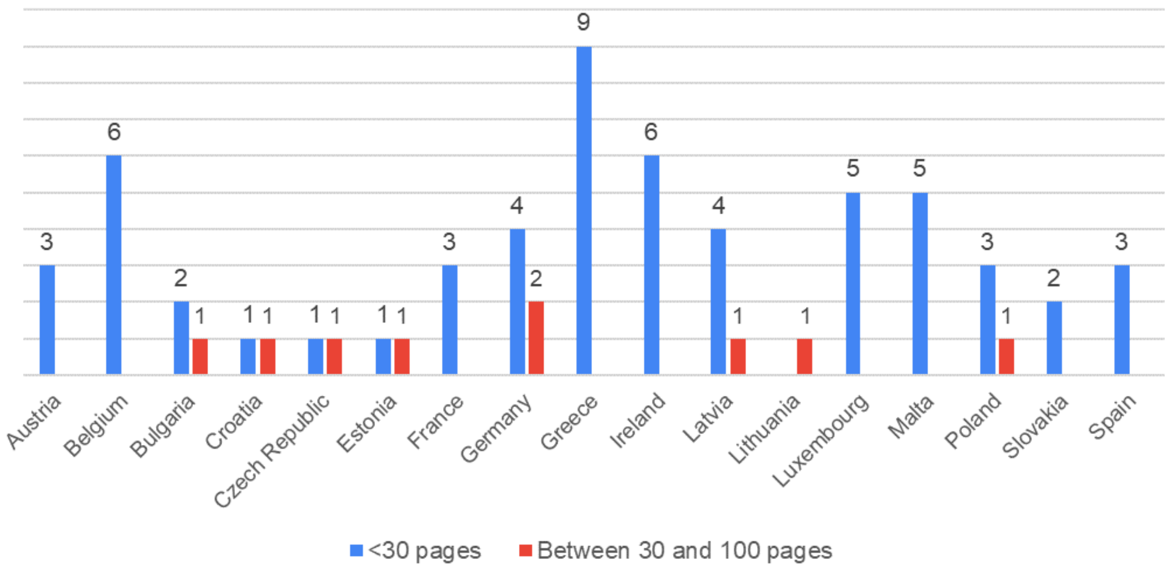
A large majority of the mapped instruments can receive applications throughout the whole year. This should be interpreted as a positive fact in terms of accessibility, as project promoters can prepare their applications without specific concerns and restrictions in terms of timing. Furthermore, as remarked by some WG members during the third batch of meetings, the possibility to apply throughout the whole year makes it easier to plan and implement a company's business and technology roadmap.

The third element analysed in terms of accessibility IsI the **length of applications**, measured in number of pages of documentation, in paper or digital format, that an applicant has to submit in order to comply with the instrument's requirements. Like for the previous two elements analysed in this section, the length of an application is not a synonym of the effectiveness of an instrument. However, **shorter applications can be generally linked to fewer administrative and bureaucratic requirements**, as less documents, extracts, certificates, and so on are required to be submitted. This would thus make the application process easier and faster for the applicants, reducing the chances that the applicant gives up on applying due to the excessive administrative requirements. Furthermore, a faster preparation of the application could also decrease the time-to-market[139], and thus increase the investment return.

During the mapping exercise, it was possible to gather information on the average length of an application for only 67 instruments available for energy production. This does not come as a surprise, as applications are usually not made available to the public and is thus difficult to obtain information on this. Out of the 67 instruments, the large majority of them (58) usually require applications up to 30 pages-in length. Nine instruments generally require between 30 and 100 pages of application (see Figure 36).

[138] It should be noted that application windows might differ significantly in terms of duration. This difference is not reflected in the mapping and, consequently, in this analysis.
[139] The time-to-market is influenced by numerous other factors other than the time necessary to prepare the application.

Figure 36: Number of schemes for H&C for which it was possible to assess the application length, per Member State



Finally, the last element considered under the accessibility analysis is the **possibility to contact the implementing entity** to ask questions and clarifications. Ideally, there should be the possibility to interact with the investor before submitting an application. This would serve especially the beneficiaries which could confirm fit to investment strategy before engaging in the potentially effort-heavy application process. This was considered important as different project promoters might face very different situations and have very different questions and conditions, which might not all be clearly addressed in the instrument's website or application manual. For this reason, having the possibility to reach out to the implementing entity to ask for clarifications is important and particularly useful for potential applicants, but also for the investors, which thereby avoid screening of applications which do not match the investments targeted. Information on whether or not it is possible to contact the implementing entity with questions on the instrument was found for only 65 instruments at Member State level available for H&C projects. For 63 of these it is possible, and only 2 of them it is not. However, it should be noted that for the large majority of the instruments mapped for H&C (235 out of the 300 in total) it was not possible to clearly determine whether contact channels were established. Therefore, it is possible that for some of those 235 instruments there is the possibility to dialogue with the implementing authority, but it is not well advertised or indicated.

It was possible to identify two instruments having all the "ideal" characteristics for an instrument effectiveness from the accessibility point of view[140], by doing a cross analysis of all the financial support schemes available for energy production. These two instruments come with an application manual with detailed information, offer the possibility to contact the implementing authority with questions and inquiries, have on average applications below 30 pages, and it is possible to apply to them anytime during the year. One instrument is in Croatia and is implemented by the Croatian Bank for Reconstruction and Development (HBOR), and one in Latvia and is implemented by Swedbank. Both instruments are loans, the one in Croatia funded by the NRRP resources, and the one in Latvia by Swedbank's own resources. Both instruments are also quite broad in scope, the one in Croatia being a special scheme for SMEs, not specific to energy but under which energy investments are eligible, and the other being a loan scheme for renewable energy (including heat pumps and solar heat) open to all five segments of the energy value chain.

[140] This does not mean that these are the only instruments having these characteristics, but rather that these are the only instruments for which it was possible to map these characteristics.

All the other instruments mapped present are characterised by different combinations of these features (e.g., short applications but only one cut-off per year, etc.). While this does not mean that those instruments are less effective than the three mentioned above, from a beneficiary/applicant perspective they represent a bigger effort to apply to. Ideally, according to consulted WG Members, instruments should keep bureaucratic and administrative requirements at a minimum necessary, so as to avoid burdening beneficiaries, particularly start-ups and SMEs. This should also result in faster and easier application processes that smaller companies and households can complete without having to rely on external support and help.

The **visibility of available instruments** was also pointed out by WG members as a challenge to instruments' accessibility and, therefore, effectiveness. While not specific to any individual scheme, WG members noted that the number of financial support schemes in some countries make it difficult for project promoters and investors to have complete visibility on the options available to support investments. On this matter, **one-stop-shops** were valued positively by WG members as a possible solution to the fragmentation and low visibility that financial support scheme can have.

Examples of effectiveness

Effectiveness in addressing barriers: evidence from the mapping and case studies

The mapping identified a number of financial support schemes and evidence of their effectiveness in addressing barriers.,which are as the mapping concentrated on ongoing instruments for which there are no formal evaluations yet, evidence was primarily collected from available news and press releases reporting on instruments' results and impacts achieved so far, as well as feedback from stakeholders consulted in the process of data collection and the views of WG Members shared in the context of the Investors Dialogue on Energy.

Grant schemes found to be effective have attracted a high number of applications and supported many projects. This suggests the schemes are effective in **improving access to finance for target beneficiaries** and in **strengthening the economic incentives** for H&C investments. A good example is the ELENA programme (European Local Energy Assistance), also because it **is easy to apply and customer oriented**. To support local and regional authorities to prepare energy efficiency and renewable energy projects, the European Commission and the European Investment Bank have launched the ELENA programme to provide technical assistance for energy efficiency (including district heating and combined heat and power plants) and renewable energies for buildings and urban transport. It has allowed private and public promoters to aggregate projects and ensure their bankability to ultimately increase financing. Indeed, it has been successful in funding several initiatives involving district heating, smart grid infrastructure and renovations through project development services. While not providing direct finance, the ELENA programme has contributed to reduce the perceived risk of heating and cooling projects, hence increasing their chances to access finance and their attractiveness towards private investors. Since its creation, ELENA has supported more than **80 projects with €150 M in grants**, mobilising nearly **€5.6 bn of related investments** leading to more than 30 000 temporary jobs.

Besides, another good example is the **French "Heat Fund" (Fonds chaleur),** which was able to finance effectively heat networks in France since 2009, and from which more than **7,100 companies and local authorities** have benefited to date. **Grants** are provided by the national government and managed by the French agency for energy ADEME. The Heat Fund was implemented in order to support the production of heat from renewable resources and recovered energy, notably through the development of the use of biomass (forestry, agriculture, production and thermal recovery of biogas, etc.), geothermal energy, heat pumps and solar thermal. The targeted sectors are collective housing, tertiary, agriculture and industry. By encouraging the use of renewable energy by heating networks, the Heat Fund also has an important social impact (reduction and stabilisation of heating bills of essentially social housing) and directly encourage overall diversification of the energy supply.

In relation to **loan instruments**, the Netherlands and HVC, a Dutch DHC operator, in relation to district heating network expansion[141] is a good example. Through a loan to HVC, the EIB supported HVC's district heating investment plan for the period of 2020-2023. The plan concerns both the expansion of district heating networks and investments in geothermal sources of energy. The amount of the loan provided by the EIB is **€ 50 M** with a total project value of **€ 224 M**.

The loan finances the development and expansion of HVC's district heating networks and heat generation capacity in several locations in the Netherlands. The project's scope comprises: (i) the extension of existing district heating networks, currently supplied with residual heat from the HVC's biomass and waste incineration plants in the municipalities of Alkmaar and Dordrecht (respectively in North Holland and South Holland provinces), and (ii) the expansion and development of geothermal heat generation activities, including the associated district heating network, in the municipality of Westland in the South Holland province.

The main purpose of the investments is to further develop the HVC's sustainable heat supply services to support the transition away from gas heating at the municipality levels. The project will reduce greenhouse gases and other local air pollutants emissions, by replacing individual natural gas fired heating sources in residential and commercial buildings as well as in horticulture greenhouses with more sustainable, centralised heat generation and by adding new renewable heat generation.

In relation to **guarantees**, a good example is a guarantee from **European Investment Bank (EIB)** that **supports an equity investment vehicle called "Dorothea"**, that will build a diversified portfolio of projects in DHC in various Dutch municipalities. Dorothea was set up by Asper Investment Management, a specialised investment firm, to acquire and build an exclusive portfolio of sustainable district heating projects in the Netherlands. The EIB is joined in Dorothea by four other leading institutional investors and will be a member of Dorothea's Investor Committee. Dorothea's first four projects are located in Ede and three other rapidly growing municipalities. They will contribute to the **decarbonisation of the Netherlands' heating sector** by using a combination of geothermal, residual heat and sustainable, locally sourced biomass. They include the construction of new district heating networks and the refurbishment of existing infrastructure. In total, the newly installed heating capacity is expected to deliver over 2 million GJ of sustainable heat. The total project cost is of **€350 million**. The EIB and Asper Investment Management Ltd. have signed an investment agreement worth **€30 million** for investments in four projects. This agreement will enable the EIB to consider additional investments into new district heating projects in the Netherlands **up to €70 million**. The EIB is backed by a **guarantee** from the **European Fund for Strategic Investments (EFSI)**, the main pillar of the Investment Plan for Europe under which the EIB and the European Commission are working together as strategic partners, with the EIB's financing operations boosting the competitiveness of the European economy. The rest €280 M of the project cost from private investors. **A scheme's ability to crowd in additional resources is perhaps the most relevant metric to assess its effectiveness**. Here, the target multiplier is **4.42**.

Besides, financial instruments can play a role in addressing investment barriers for heating and cooling, as shown in the two following examples:

- **Urban H&C projects are usually considered as very risky** by most private financial institutions, and therefore do not receive sufficient investments. The **REUSEHEAT project** was mentioned by some WG Members as an interesting example to address

[141] HVC DISTRICT HEATING NETWORK EXPANSION (eib.org)

this issue. The project proposes a **credit facility**[142] that foresees a **long-term financing** made available by an Institutional Bank, acting as sponsor, to one or more commercial banks in the EU and the issue of a credit guarantee fund by national or supranational entities aimed at covering risks related to technology or the urban waste heat source. The risks related to the default of the project promoter or to other financial causes are not covered by the public guarantee and are borne by the commercial bank. Within this scheme, the key incentive would be constituted by the risk sharing facility rather than by the funding line, since the lack of liquidity for banks was not identified as a key issue by the REUSEHEAT analysis.

- **The risk of not finding an economically sustainable geothermal resource after drilling is one of the main barriers that geothermal project promoters face**. In this context, a guarantee scheme could be relevant to reduce the risk. The **GEORISK**[143] **project** was proposed as an example. The project establishes a risk insurance all over Europe and in some third countries to cover risks associated with the development and the operation of a deep geothermal plant. Public insurance schemes provide financial support in case the risk.[144]

In relation to **equity instruments**, the mapping identified a few interesting schemes:

- The **EIF's Climate and Infrastructure Fund (C&IFs)**[145] supports investments in climate action and environmental sustainability, which account for around **70%** of the portfolio. Under this Facility, the EIF provides **equity investments** to, or alongside, climate & infrastructure funds. InvestEU investments are organised into six Thematic Strategies. **Heating and cooling** falls under Clean Energy Transition & Climate thematic strategy. The EIF aims to support between 8 to 12 funds per year with operations targeting financial intermediaries focusing mainly on greenfield investments, climate action and environmental sustainability. At least 60% of an investee fund's capital needs to be invested in greenfield, expansion or retrofit/ refurbishment projects. The C&IFs invest in H&C by targeting funds whose investment strategies target: Decarbonising H&C infrastructure (including networks) in buildings or other facilities; Production, storage, transmission and distribution infrastructure for wind, solar, geothermal, hydro, bioenergy and other technologies; Infrastructure for the production of heat and cold, renewable electricity, low-carbon gases. The C&IFs facility makes investments in funds and side vehicles of funds providing equity or equity-type debt capital to infrastructure assets. The intermediary has to invest in **infrastructure projects** either directly (e.g., through a SPV) or through **developers**, and needs to predominantly focus on greenfield or other capex-related investments (expansion, refurbishment, etc.), primarily in the EU27, alongside neighbouring countries.
- The **EIB's European Growth Finance Facility** provides **venture debt (quasi-equity)** to address the **unique funding needs of fast-growing innovative companies**. The financing structure includes bullet repayment and remuneration linked to the equity risk of the investees and complements existing venture capital financing. The EIB provides venture debt from **€7.5 M up to €75 M**, covering maximum 50% of the total capital needs (meaning that the investee needs to put at least the same amount as provided by the EIB). The instrument targets mainly highly innovative companies that suffer from systemic failure in terms of access to non-dilutive, risk-absorbing growth capital across the EU. EIB supported **Viking Heat Engines**[146] for the industrialisation of its innovative equipment to recover energy from low temperature industrial (waste) heat sources, and convert it into electricity or higher temperature suitable for re-use. The project

[142] REUSEHEAT. Bankability. https://www.reuseheat.eu/wp-content/uploads/2019/06/D2.2.-Bankability.pdf

[143] Georisk Project. www.georisk-project.eu

[144] https://www.georisk-project.eu/wp-content/uploads/2020/03/D3.4-Proposal-for-a-transition-in-the-Risk-Mitigation-Schemes.pdf

[145] EIF. Climate & Infrastructure Funds. https://www.eif.org/what_we_do/equity/climate-and-infrastructure-funds/index.htm

[146] EIB. Viking Heat Engines (EGFF). https://www.eib.org/en/projects/pipelines/all/20160749

helped the company implement its planned 2017-2019 activities, investments and expenditures to scale up its manufacturing processes, and further develop its technology. The EIB provided **€30 M** of direct quasi-equity financing (for a total project cost of €89 M). The financing was supported by the EFSI.

Concerning effective bond instruments, the two following examples are relevant:

- In 2013 the **City of Gothenburg** was the first in the world to use the framework for green bonds that SEB has developed together with the World Bank Group and another of Swedish investors. The issue in 2013 of **SEK 500 M** (€ 58.2 M) is part of an issue programme from the City of Gothenburg that could lead to 2 billion. In May 2014 there was an announcement of a second bond from the City of Gothenburg. The issue of SEK 1.8 billion (€ 210 M) received “tremendous” interest. The Green Bond Programme and funds are used primarily to support projects that counter or help adapt to climate change. As part of the environmental programme, the City of Gothenburg continues to issue bonds for financing various environmental projects in the areas of renewable energy, public transport, water treatment, energy efficiency, smart grids, urban planning and waste management.
- **Stockholm Exergi** is the local energy company of Stockholm, owned by the City of Stockholm and Fortum. In 2019, they provide heating for more than 800 000 people in metropolitan Stockholm and cooling for more than 400 properties, hospitals, data centres and other. A **Green Bond Framework** was first issued in 2015, then adapted in 2019. This Framework defines the projects and investments eligible for financing by green bonds. Over the past 20 years, the heated area connected to district heating in Stockholm has **more than doubled**. At the same time, total emissions from district heating have decreased by more than 55%, meaning that the emissions per heated property area have decreased by more than 78%. This sharp decrease has been achieved together with property owners and businesses’ own energy efficiency improvements and replacements of fossil-based heat production. As per December 31st, 2022, Stockholm Exergi had in total issued 10 green bonds with a total nominal amount of 6 700 MSEK (€590 million).

Concerning technical assistance, the **JASPERS programme** (Joint Assistance to Support Projects in European Regions) was also identified as a good **technical assistance and project preparation facility**. This programme does not provide financing but provides the following types of support: strategies and plans, advisory support in project preparation, project-appraisal support, and capacity building. The energy sector is part of the sectors targeted, with notably projects aiming at rehabilitating and decarbonising district heating plants and networks to reduce energy losses and carbon footprint. However, some WG participants noted that it should be combined with financing opportunities, so as to expand its scope and impact.

Effectiveness in mobilising private finance

An important element of an instrument’s effectiveness is its multiplier effect, that is the instrument’s capacity to attract additional private financing compared to the instrument’s initial public budget, and channel funds to the targeted projects. By crowding in and unlocking private financing, financial instruments aim to **increase the overall capital available** to achieve EU policy goals more efficiently[147].

[147] In addition to the multiplier effect, impact indicators (e.g., tons of CO2 avoided, jobs created) are also important to assess the effectiveness of financial instruments. This section focuses exclusively on the multiplier effect as the mapping did not provide information on the impact generated by ongoing financial schemes. As such, this section should not be interpreted as a complete evaluation of the effectiveness of instruments in the mapping but rather as a presentation of findings related to their crowd-in potential. Crowding in of private funds in turn remains an important feature of financial instruments, as the initial public budget allocated to an instrument is typically not enough to cover all the investment costs and to ensure a timely deployment of the underlying target investment(s).

Because an instrument's multiplier is usually only calculated as part of evaluations conducted at the end of the instrument's life, the mapping was able to provide very limited information on the achieved multiplier effects or amount of additional investment crowded in.

It was possible to identify the target multiplier for 7 of the mapped guarantee schemes for heating and cooling. However, since they are all recently implemented and ongoing instruments, the actual multiplier is not yet available. As can be noticed from Table 4 below, all of the mapped schemes have a target multiplier between 1.4 and 2. It should be noted that most of the schemes listed below are not specific to the energy sector, but heating and cooling projects are technically eligible to obtain financing.

Table 4: Mapped Guarantee Schemes with a target multiplier

Name	Member State	Implementing entity	Target multiplier
Investments in improved energy efficiency in industrial processes	Bulgaria	BEERSF	1.4-2
Bulgarian Energy Efficiency and Renewable projects for individuals	Bulgaria	BEERSF	1.4-2
Expansion Guarantees	Czech Republic	National Development Bank	1.25-2
Inostart Guarantee for start-ups.	Czech Republic	National Development Bank, Česká spořitelna	1.4-2
InnovFin	Czech Republic	Česká spořitelna	2
TOP INNOVATIONS 4.0	Czech Republic	Česká spořitelna	1.4-2
Co-financing framework	Greece	EIF	2.75

Mapped guarantee schemes for energy heating and cooling have a lower target multiplier than what was achieved by ERDF/CF[148] guarantee schemes in the previous Multiannual Financial Framework 2014-2020. More specifically, ERDF/CF guarantees achieved a median multiplier of 4.8 at the end of 2020[149]. This lower ambition in mobilised resources could signal some **constraints in the current use of guarantees to mobilize larger volumes of private capital** for heating and cooling projects, or that energy guarantees tend to focus on riskier projects. This seems to be a characteristic common to other guarantees for energy projects mapped by the ID-E team.

[148] European Regional Development Fund / Cohesion Fund.

[149] European Commission. Financial instruments under the European Structural and Investment Funds Summaries of the data on the progress made in financing and implementing the financial instruments for the programming period 2014-2020 https://www.fi-compass.eu/sites/default/files/publications/summary_data_fi_1420_2020.pdf

Concerning the **target multiplier** of instruments in the sample, the Table 5 compares the target multiplier for loans and guarantees in the mapping against the achieved leverage effect for similar types of instruments implemented under ERDF and CF in the 2014-2020 programming period. No equity vehicles for H&C were found to have a declared multiplier. It should be noted that, in most cases, the mapping considered the target multiplier as the ratio of target private finance attracted based on the amount of public financing. On the other hand, the achieved leverage effect for the instruments included below considers the total amount of finance reaching final recipients divided by the public (ESIF) support. As a result, target multipliers from the mapping are likely to have lower values compared to achieved leverage figures. The information presented below should therefore be used for general observations rather than for making exact comparisons on the effectiveness of current and past instruments. Grants have been excluded from this analysis as the intention behind grant support is not typically to generate simultaneous private co-investment but rather to cover part of the costs of the project and support early-stage projects so that they can access private investment at a later stage.

Table 5: Average target multiplier by type of instrument in the mapping[150]

Type of financial instrument from mapping	Average target multiplier from mapping	Median achieved leverage as at 31 Dec 2020 – financial instruments under ERDF/CF
Loans	1.66x[151] (based on 17 instruments with available target multiplier)	1.3x (based on 451 instruments)
Guarantees	1.61x(based on 7 instruments with available target multiplier)	4.8x (based on 87 instruments)

Summary findings on instrument relevance and effectiveness

- **Evidence from the mapping on the relevance of financial instruments for addressing investment barriers** affecting energy production projects indicates that:
    1. **Financial instruments for H&C investments are primarily relevant for targeting investment barriers related to the availability of finance, financing conditions and market risk of energy production projects**.
    2. **Financial instruments are not relevant for addressing regulatory barriers or those related to supply of labour**. A similar situation can be said to apply to the barriers related to **administrative requirements** or **resource risks**, which are caused by elements outside the financial market landscape, despite affecting it.
    3. **The mapping seems to suggest that there is further need for (i) schemes that at design level facilitate the aggregation of smaller projects, and (ii) schemes combining the provision of finance with technical assistance support.** This should support in further tackling barriers related to **project pipeline fragmentation or scarcity**, and to limitations in promoters' **planning and preparation capacity.**

[150] European Commission (2021). Financial instruments under the European Structural and Investment Funds – Summaries of the data on the progress made in financing and implementing the financial instruments for the programming period 2014-2020.

[151] In the case of instruments presenting a numerical range for their targeted multiplier e.g., 1.4-2x, the calculation of the average considered midpoint values (1.7x in given example). Combined loan/guarantee instruments were taken into account both for the calculation of the average target multiplier for loans and separately for guarantees.

- **Examples of mapped instruments found to be effective in addressing barriers include grants, low-interest loans, equity schemes, a portfolio guarantee instrument and green bonds**[152] **in a number of EU Member States.** In general, evidence of the schemes' effectiveness could be seen from the **interest shown by the private sector** (final beneficiaries, banks, potential equity co-investors) in the different schemes. More specifically, and considering the different types of instruments mapped:

    1. For grant schemes, evidence of their effectiveness in improving availability of finance and the economic incentives for target recipients was seen through a **high number of applications**[153] **and/or a high number of projects supported** under such schemes**.**
    2. Effective loan schemes similarly financed a **large number of projects**, or, in the case of more recent instruments, received **active interest from project promoters and already achieved inaugural investments**.
    3. For equity schemes, evidence of their effectiveness in improving the availability of equity financing for renewable energies and innovative technologies was seen through the schemes' **successful fundraising activities**, or, in the case of more recent schemes, from the **active interest shown by private investors** to co-invest in the schemes.
    4. In the case of the portfolio guarantee agreement concluded recently between EIF and a commercial bank in Lithuania, evidence of the instrument's good potential to de-risk and catalyse RE investments could be seen from the bank's expectation/intention to use the guarantee in order to finance new RE **projects earlier during their construction and development phase.**
    5. In the case of green bond issuances, evidence of their effectiveness in amplifying medium/long-term finance for RE projects was seen through **strong and diverse investor demand for the issued bonds.**

- **The mapping provided limited information on the multiplier effect (current or target) of currently active financial instruments.** Loan instruments from the mapping show on average a slightly higher target multiplier than comparisons from the literature, which could signal a good potential for current active loan schemes to mobilise private capital for energy projects. Guarantee schemes showed the highest deviation (i.e., lower target multiplier results) compared to examples from the literature. This could be due to differences in multiplier/leverage calculation methodologies as well as due to some remaining constraints in the current use of guarantees to mobilise large volumes of private capital.

[152] As referred in Section 4.2.2., bond instruments were identified through separate desk research and are not included in the mapping.

[153] While the number of applications alone is not sufficient to define the effectiveness of a grant, it is nonetheless essential to define its uptake, attractiveness and visibility in the market, which are key elements of effectiveness

5. Level of maturity of EU clean energy finance markets

This section analyses the level of maturity of clean energy finance market, focusing particularly on the heating and cooling sector of EU Member States. The aim is to assess to what extent each Member State has an energy finance market and overall enabling environment that is fit for delivering the ambitious goals of the EU energy transition agenda and, more specifically, of Heating & Cooling. The section is organised as follows:

- Section 5.1 provides an overview of the approach adopted to assess clean energy finance maturity using a framework based on three critical dimensions: Supply of Clean Energy Finance, Availability of Public Finance, and Cost of Financing (WACC)
- Section 5.2 delves into the identified trends and indicators that offer insights into the maturity of clean energy finance markets, with a specific emphasis on heating and cooling initiatives. From private financing avenues to public finance mechanisms, we explore the multifaceted dimensions influencing the growth and sustainability in the context of heating and cooling. These sections collectively contribute to a nuanced understanding of the financial ecosystems that underpin the advancement of energy-efficient technologies and practices within EU.

5.1. Approach to assessing market maturity

Financial markets and regulatory systems that are able to efficiently allocate capital to clean energy projects and offer appropriate risk-adjusted returns, are a necessary precondition for clean energy finance mobilisation. Financing the energy transition will also require a large-scale mobilization of private capital, and an enhanced role for international and public finance institutions[154]. This means that the public sector and the private financial sector must be able to jointly provide financing that is (i) adequate in terms of volume (ii) with appropriate and relatively cheap[155] terms and (iii) diversified and covering a broad range of market readiness levels, needs and target beneficiaries/clients.

With these considerations in mind, we have developed a framework to assess the maturity of clean energy finance markets, based on three dimensions. Table 6 summarises the framework, as well as which indicators and metrics we have selected to assess the three dimensions.

Table 6: Characteristics of mature clean energy finance markets, and how our analysis will assess them.

Market maturity characteristics	**Description** *Why we have chosen this characteristic*	**Key metric/indicators** *How we will measure it*
Abundant supply of energy finance, primarily from the private sector, with the public sector intervening in underserved	• The deployment of renewable H&C technologies to mitigate carbon emissions typically requires high upfront investment[156,157]	To evaluate the supply of finance, we will use the following indicators: • The availability of private finance in each Member State, measured through:

[154] IEA (2021), *Financing clean energy transitions in emerging and developing economies*, available on link

[155] Relatively to specific risk-return conditions and the macroeconomic landscape

[156] Steckel JC, Jakob M, Flachsland C et al (2017) From climate finance toward sustainable development finance. Wiley Interdiscip Rev Clim Chang 8:e437. https://doi.org/10.1002/wcc.437

[157] Tietjen O, Pahle M, Fuss S (2016) Investment risks in power generation: a comparison of fossil fuel and renewable energy dominated markets. Energy Econ 58:174–185. https://doi.org/10.1016/j.eneco.2016.07.005

Market maturity characteristics	**Description** *Why we have chosen this characteristic*	**Key metric/indicators** *How we will measure it*
markets	• Best (2017)[158] finds that across countries, the availability of financial capital contributes to investments in more capital-intensive energy technologies. For high-income countries, financial capital supports transitions towards more capital-intensive energy technologies. • In terms for sources of funding, while it is clear that both public and private H&C financing is needed, they should play very different roles in financing the energy transition. Public sector financing should be directed to underserved markets, emerging technologies, addressing market failures and investing in riskier areas. Private sector finance, on the other hand, should be able to provide the supply of debt and equity finance needed in the market, covering a wide range of levels of technology maturity with a diverse offer of instruments	○ Banking debt of corporates ○ Stock market capitalisation ○ Green bond market • The availability of public finance to finance H&C in each Member State.
Low cost of capital - WACC	• The weighted average cost of capital (WACC)[159] is one of the most important financial variables for low-carbon infrastructure, given their capital-intensive nature and high upfront costs (Dukan et al., 2019)[160]. • The WACC incorporates the level of interest rates and several country risks, such as regulatory, economic, political and legal. Furthermore, WACC can also reflect technological advancements and increased experience in the energy financing sector, signalling a high level of maturity. • For these reasons, low values of WACC signal mature energy finance markets and a low country risk.	To evaluate the cost of capital, we have calculated the WACC for renewable energy projects in each Member State.
Presence of a	• H&C projects are financed mainly with project-level conventional (i.e., non-concessional) debt, which accounted for 32% of the total RE investment in 2017-	Comprehensive data on the instruments used for investments in renewable energy is not available. To evaluate the diversity and comprehensiveness of financial

[158] Best R (2017) Switching towards coal or renewable energy? The effects of financial capital on energy transitions. Energy Econ 63:75–83. https://doi.org/10.1016/j.eneco.2017.01.019

[159] The formula to calculate the WACC is presented below:

WACC=DD+E*Cd*1-t+ ED+E*Ce

- *D* is the market value of a firm's debt
- *E* is the market value of a firm's equity
- *Cd* is the cost of debt
- *t* is the corporate tax rate
- *Ce* is the cost of equity

[160] Dukan, M., Kitzing, L., Brückmann, R., Jimeno, M., Wigand, F., Kielichowska, I., Klessmann, C., & Breitschopf, B. (2019). *Effect of auctions on financing conditions for renewable energy* (Issue May).

Market maturity characteristics	Description *Why we have chosen this characteristic*	Key metric/indicators *How we will measure it*
diverse set of financial instruments, including the use of 'sophisticated' financial instruments, such as bonds and equity, and a low use of grants for mature technologies	2018, on average[161]. • The availability of grants can signal the presence of many early-stage technologies in the market. However, an excessive use of grants signals low maturity of the energy finance market, which is too dependent on free public support. This is especially concerning if grants are deployed for mature technologies that are already capable of accessing private financial markets. • Considering the above, we consider as mature those markets that have a balanced mix of financial instruments, including 'sophisticated' instruments such as bonds and equity. On the other hand, markets that rely solely or mainly on grants and loans can be considered less mature.	instruments available in each country, we will use the following indicators: • Diversity of financing instruments for H&C, measured through a repurposed use of the Herfindahl-Hirschman Index (HHI) • Number of categories of 'sophisticated' financial instruments offered in the Member State. • Grants for rollout stage projects as a % of grant instruments To compute the indicators above we have used the data of the mapping of financial instruments presented in Section 3 of this report.

5.2. Trends on market maturity identified

This section provides an assessment of the maturity of the clean energy finance markets of each Member State, based on the three dimensions presented in the previous section.

Supply of clean energy finance

The availability of private finance indicates a healthy financial system, while public financing should serve specific policy goals and address market failures. Comprehensive data on private and public RE investments broke down for each EU Member State, are currently not easily accessible. We can however extrapolate the supply of clean energy finance from a series of data points. In the rest of this section, we analyse the indicators chosen to assess the supply of finance for clean energy investments, as described in Section 5.1.

Availability of private finance: bank financing and capital markets

Below we present the three key metrics that will be used to measure the availability of private finance in each Member State, although none of this metric is specific to the energy sector. These metrics reflect criteria on private market financing used in the IMF Financial Development index.

Bank financing

Bank financing is the main source of external finance for firms of all sizes in the European Union. Data from EIBIS 2021 shows that, on average, bank loans represented 59% of external funding for companies in the EU. An adequately high, but sustainable, stock of debt to non-financial corporates can be an indicator of a well-functioning banking system. In countries where the banking system is in distress or constrained by high cost of financing or high ratios of non-performing loans, financial institutions will limit their lending to corporates and

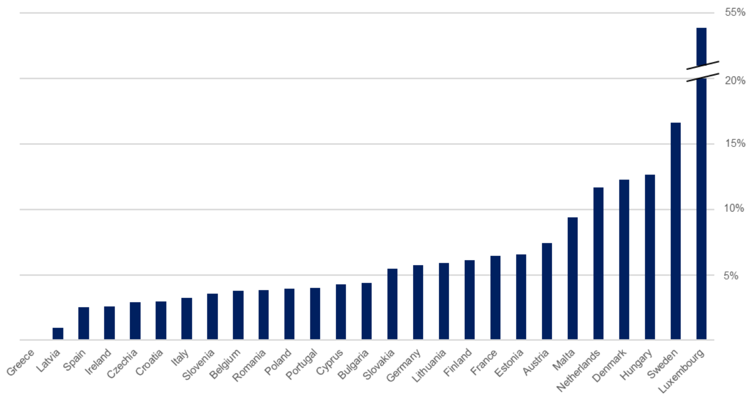
[161] Source: IRENA (2020), *GLOBAL LANDSCAPE OF RENEWABLE ENERGY FINANCE 2020*, available at: Link

households. The banking indicator reported by the European Central Bank, can be used as a proxy of the amount of credit and debt financing that firms can access in each Member State.

Banks play a crucial role in providing financing for clean energy projects in the heating and cooling sector. They offer various financial products, such as loans and credit facilities, to support the development and implementation of clean energy technologies. These funds can be used for investments in energy-efficient heating and cooling systems, renewable energy integration, and other sustainable initiatives.

Bank financing for clean energy projects typically involves assessing the creditworthiness and viability of the projects. Banks evaluate factors such as the project's financial feasibility, technology maturity, regulatory environment, and potential revenue streams. Based on these assessments, they provide loans and financial assistance with favourable interest rates and terms to facilitate the adoption of clean energy solutions in the heating and cooling sector. Figure 37 presents the ratio of debt securities and loans within the private non-financial sector relative to the Gross Domestic Product (GDP) in the year 2021.

Figure 37: Debt securities and loans of the private non-financial sector as a ratio of GDP, 2021

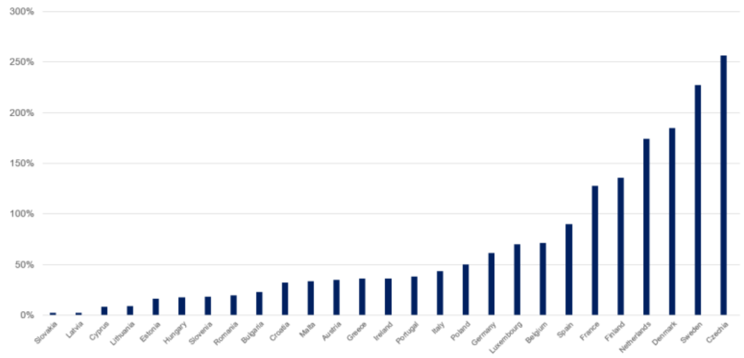


Source: European Central Bank[162]

Stock market

The following stock indicator is generally used as a measure of under – or – over-valuation of a country's stock market[163]. For the purposes of our analysis, it is used as an indicator of access to equity capital markets (see Figure 38).

Figure 38: Stock market capitalization as % of GDP (2021)



162 Available at: Link

163 Stock Market Capitalization-to-GDP Ratio: Definition and Formula, available at: Link

Source: CEIC[164]

The stock market also plays a role in providing finance for the heating and cooling sector. Investors, including institutional investors and individual shareholders, can invest in publicly traded companies that operate in the clean energy space. These companies may be involved in manufacturing energy-efficient heating and cooling equipment, developing renewable energy technologies, or providing energy management solutions.

Investors interested in supporting the heating and cooling sector can buy shares of these companies, thereby providing them with capital for research, development, and expansion. The stock market investments contribute to the overall growth and development of the sector by attracting funds from a wide range of investors and facilitating liquidity for companies involved in clean energy solutions.

Green bonds

The green bonds indicator can help understanding the extent to which investments in the heating and cooling sector can be covered by the issuance of green bonds. Examples of project financed through green bonds in the H&C sectors include energy-efficient building retrofits, installation of renewable heating and cooling systems, or the development of district heating and cooling networks. Investors who purchase green bonds provide capital to the issuers, who then allocate the funds to projects with positive environmental impacts.

According to data from the Climate Bonds Initiative[165], energy represents on average 44% of the use of the proceeds of Green Bonds issued in Europe, between 2014 and the first half of 2022, equivalent to over USD 32 billion. This is a proxy of at least part of the RE investments financed via bond issuance, as the energy investments financed by Green Bonds are by definition in clean energy, otherwise the bond could not be labelled as 'Green' according to international standards[166]. The Figure 39 shows the stock of green bonds (in USD millions) in 23 EU countries[167] issued as of the first half of 2022 as share of their GDP[168]. This analysis allows to compare bond issuance to the relative size of a country's economy. Larger Member States have issued more green bonds than smaller ones, but such larger issued amounts sometimes represent a smaller share of that country's GDP. For instance, Germany and France are the two countries with the highest issued amounts, but rank 7th and 4th, respectively, in terms of issuances as share of their GDP. Italy has issued in total the 6th highest amount, but ranks only 14th if the issued amount is assessed proportionally to Italy's GDP. Luxembourg is the country with the highest green bond issuance if assessed in relation to its GDP (15.1%), despite being 11th in terms of absolute amounts.

[164] Available at: https://www.ceicdata.com/en/indicator/market-capitalization--nominal-gdp

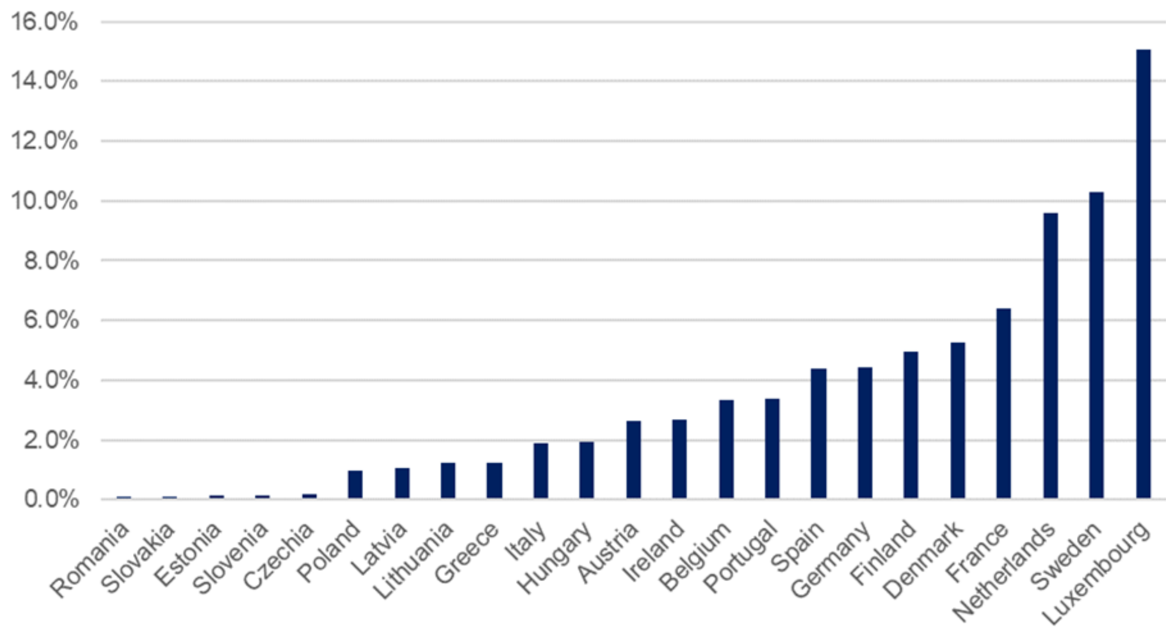
[165] Available at: https://www.climatebonds.net/market/data/#use-of-proceeds-charts

[166] International Capital Markets Association (ICMA), 2021 Green Bond Principles, available at: Link

[167] Green Bonds data have been extracted by the Climate Bonds Initiative database, which did not include all EU-27 countries. Available at: https://www.climatebonds.net/market/data/#use-of-proceeds-charts

[168] World Bank data on GDP per capita data (USD current, 2021). Available at: Link

Figure 39: Ratio between Green Bond market size (USD million, as of H12022) and GDP (USD, 2022)



Source: Climate Bonds Initiative[169], The World Bank[170]

Further information on the green bond market in EU countries can be found in the box "*Focus on: Bonds financing for energy and sustainable activities"* in Section 3.

In summary, the supply of clean energy finance in the heating and cooling sector is facilitated through bank financing, stock market investments in clean energy companies, and the issuance of green bonds. These financing channels contribute to the growth of the sector by providing funds for the development and implementation of energy-efficient and sustainable heating and cooling solutions.

Availability of public finance

When it comes to the energy sector, public finance represented on average 14% of total investments in renewables between 2013-2018[171]. The role of the public sector, and public financial institutions in particular, is to address market failures and intervene in underserved markets, achieving additionality and providing financial resources where they are scarce and/or unaffordable. Public financing resources, although limited, can be crucial to reduce risks, overcome initial barriers, attract private investors and bring new markets to maturity[172].

Data on public investment in H&C is not available, but it is nonetheless possible to use data on investments in RE collected by IRENA[173] (see Figure 40), which provides a relevant indicator of the volumes of financing channelled sector by the public sector towards energy investments, H&C included. Public RE investments collected by IRENA are largely financed by the EIB (74.2% of the total) via standard loans (98% of the total). Therefore, the analysis of this data should be interpreted with the limitation that it does not capture the full spectrum

[169] Available at: https://www.climatebonds.net/market/data/#use-of-proceeds-charts

[170] Source of GDP per capita data (USD current, 2021): https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?end=2019&locations=EU&start=2019

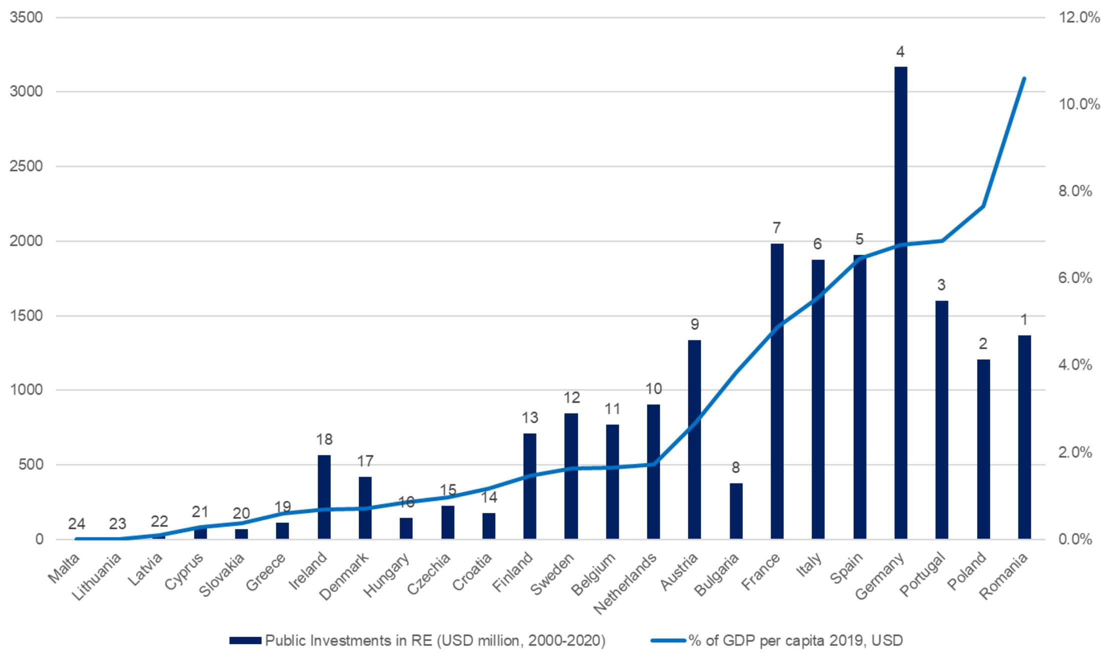
[171] IRENA (2020), *GLOBAL LANDSCAPE OF RENEWABLE ENERGY FINANCE 2020*, available at: https://www.irena.org/publications/2020/Nov/Global-Landscape-of-Renewable-Energy-Finance-2020

[172] Ibid

[173] Available at: https://www.irena.org/Data/View-data-by-topic/Finance-and-Investment/Renewable-Energy-Finance-Flows

of RE public financing. Aggregated data for 24 EU Member States[174], between 2000 and 2020, has been adjusted for the size of the economy of each Member State.

Figure 40: Public investments in renewable energy in the EU.



Source: IRENA, The World Bank

Public finance plays a significant role in supporting the cooling and heating sector by providing funding and incentives for projects related to energy efficiency, renewable energy integration, and sustainable heating and cooling systems. Governments at various levels, international organizations, and public entities contribute to the availability of public finance in the following ways:

- Government Grants and Subsidies: Governments often provide grants and subsidies to promote the adoption of energy-efficient heating and cooling technologies. These financial incentives are designed to reduce the upfront costs and make clean energy solutions more affordable for individuals, businesses, and organizations.

  Government grants may be allocated for research and development initiatives, demonstration projects, pilot programs, or the installation of energy-efficient heating and cooling systems. These funds can help overcome financial barriers and encourage the widespread adoption of sustainable technologies in the sector.

- Energy Efficiency Programs: Governments establish energy efficiency programs that offer financial support and incentives for improving the energy performance of buildings, including heating and cooling systems. These programs aim to reduce energy consumption, lower greenhouse gas emissions, and enhance energy security.

  Energy efficiency programs may provide financial assistance for building retrofits, energy audits, the installation of energy-efficient heating and cooling equipment, and the adoption of smart energy management systems. Public finance is often made available through these programs to incentivize energy efficiency improvements in the cooling and heating sector.

[174] Data on Slovenia, Estonia and Luxembourg are not available

- Development Banks and Financial Institutions: Development banks and financial institutions play a vital role in providing public finance for the cooling and heating sector. These institutions offer specialized financing programs and loans tailored to support sustainable projects.

  Development banks provide long-term financing and technical assistance for large-scale heating and cooling infrastructure projects. They may finance the development of district heating and cooling networks, renewable energy integration, and energy-efficient solutions. Financial institutions, including public banks, offer loans and credit facilities to individuals, businesses, and organizations seeking to invest in clean energy technologies for heating and cooling purposes.

- International Funding and Climate Finance: International organizations and initiatives provide financial support for clean energy projects in the heating and cooling sector, particularly in developing countries. Climate finance mechanisms, such as the Green Climate Fund, provide grants, concessional loans, and technical assistance to support climate mitigation and adaptation efforts.

  International funding can be directed towards renewable energy integration, energy-efficient building retrofits, and sustainable heating and cooling systems. These funds help bridge the financing gap and enable developing countries to access public finance for clean energy projects in the sector.

By making public finance available for the cooling and heating sector, governments, international organizations, and public entities aim to drive the transition to cleaner and more sustainable energy solutions. These financial resources encourage the deployment of energy-efficient technologies, reduce greenhouse gas emissions, and contribute to the overall decarbonization and sustainability goals.

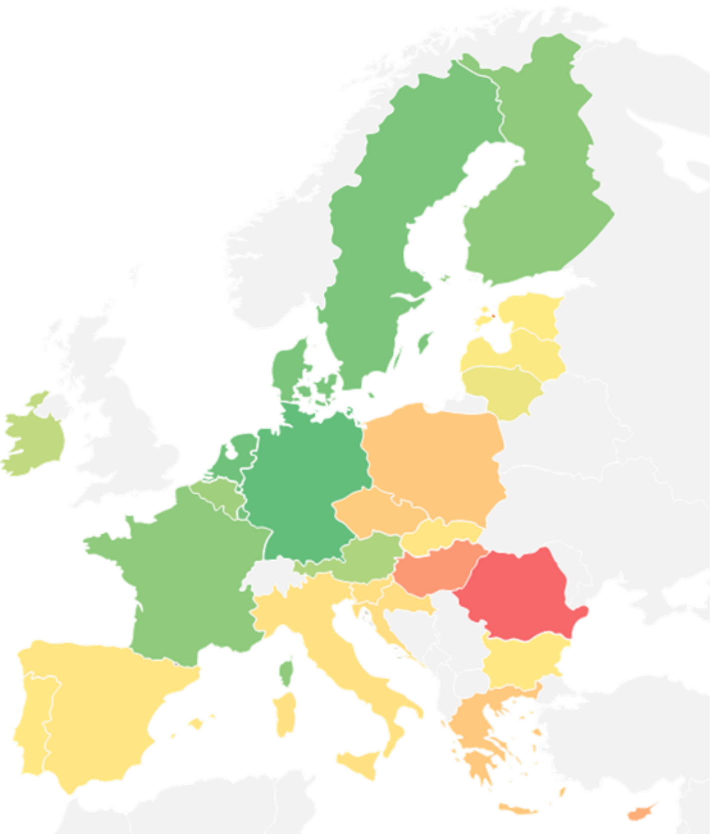
Cost of financing – Weighted Average Cost of Capital (WACC)

The cost of capital plays a vital role in evaluating investors' risk and return preferences, as well as determining the value of money within the broader economic landscape. It serves as a lever that can influence financial flows and impact prices and choices in the real energy sector. However, decision makers often face challenges due to the lack of reliable financing metrics across various sectors and regions, particularly in emerging and developing economies. Insufficient understanding of the cost of capital can result in misjudging the level of risk, potentially leading to underinvestment or overinvestment in different markets and sectors. This, in turn, has implications for the smooth progression of energy transitions.

The cost of capital expresses the expected financial return, or the stipulated minimum rate, for investing in a company or in a project. This expected remuneration is intricately connected to the level of risk entailed in the cash flows of said company or project. For the scope of this Study, the WACC of renewable energy was used as a proxy for renewable heating and cooling. Heat production and equipment are not categories in the Aswath Damodaran database that was used to calculate the WACC, and combining renewable energy’s WACC with homebuilding’s or construction’s values would

A low WACC of renewable energy (RE) projects can be considered an indicator of maturity of the clean energy finance market. Indeed, it reflects abundance of capital at relatively low cost and a low country risk, thanks to a regulatory and economic environment that enables RE investments. The Figure 41 shows that WACC of RE projects in the EU, calculated for the purposes of this report based on the latest data available. It should be noted that the WACC values are influenced by national/ European monetary policies and Central Banking. In particular, countries with higher free interest rate correspond to higher WACC values. As a result, the comparison of countries based on their WACC is especially valid among the 20 countries of the Eurozone. Details on the calculation and data sources are available in Annex 3: WACC Calculation.

Figure 41: WACC of RE projects across the EU



Country	WACC RE 2022
Romania	12.30%
Hungary	10.26%
Cyprus	9.31%
Greece	8.24%
Poland	8.20%
Czechia	8.09%
Croatia	7.36%
Slovenia	7.25%
Italy	7.17%
Spain	7.01%
Slovakia	7.00%
Portugal	6.90%
Bulgaria	6.87%
Estonia	6.73%
Latvia	6.69%
Lithuania	6.51%
Malta	6.12%
Ireland	5.99%
Austria	5.77%
Belgium	5.59%
Finland	5.50%
France	5.39%
Sweden	5.17%
Denmark	5.15%
Luxembourg	5.10%
Netherlands	5.01%
Germany	4.85%

Source: Statista, Aswath Damodaran (Stern, New York University), IRENA

Comprehensiveness and diversity of financial instruments for heating and cooling

Analysis of the data from the mapping of energy financial instruments conducted as part of the present study sheds further light on the availability and relevance of financial instruments for H&C at Member State level and how the complement the analysis of market maturity.

Diversity of financing instruments for heating and cooling

A first proxy of the diversity of mapped financial instruments available for each Member States can be obtained through a repurposed use of the Herfindahl-Hirschman Index (HHI)[175]. In the current case, the HHI, which is a measure of market concentration and is used to determine market competitiveness, shows the concentration of identified financial instruments among different types of instruments. In other words, countries with a high HHI (up to 10,000, in the case of one single type of instruments) offer a low variety of financial instrument types, whereas countries with a low HHI (nearing 0) provide a more diverse set of instruments that come with specific answers to different investment barriers and needs.

It should be noted that some of the mapped financial schemes combine different kinds of instruments. In the mapping, those were consistently tagged in several categories of financial

[175] Investopedia 2022, Herfindahl-Hirschman Index (HHI) Definition, Formula, and Example, available on: Link

instruments. Nevertheless, this does not change the interpretation that can be made for financing instruments.

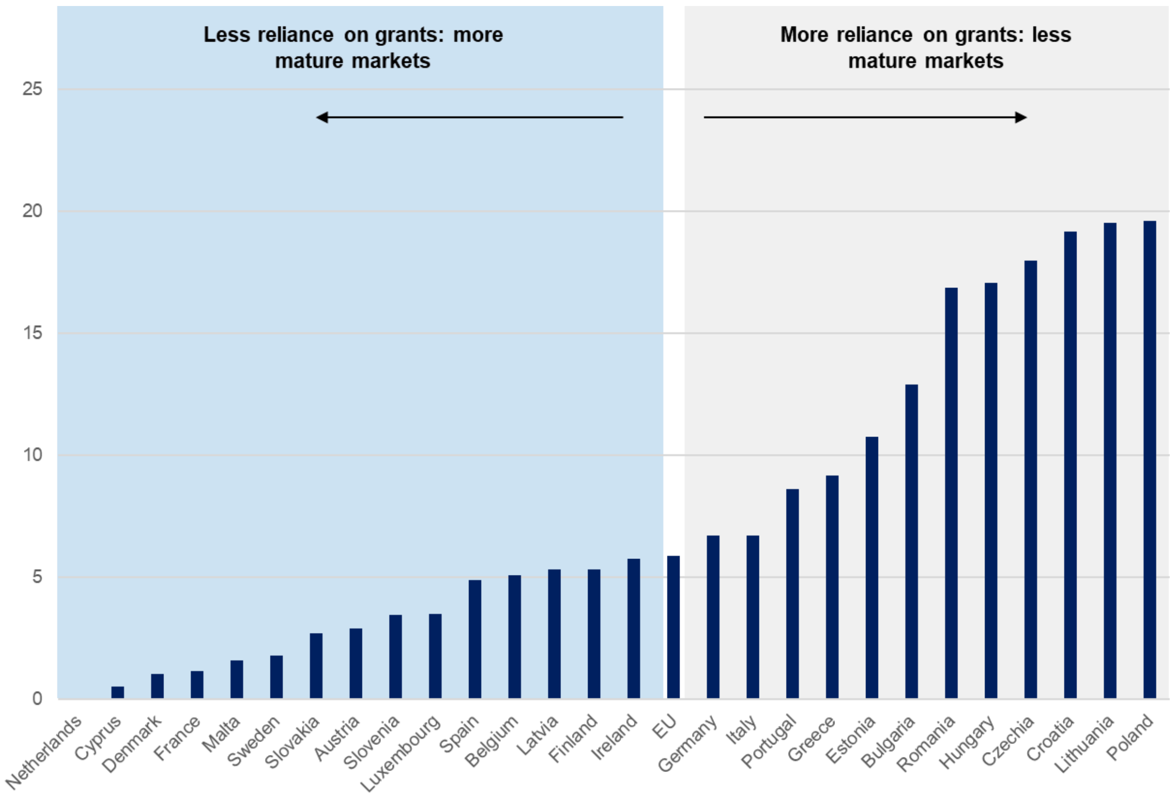
The obtained HHI values for each Member State are available in the Table 7 at the end of this section.

Grant-based instruments and share of grants open for rollout stage projects

In general, markets with a balanced mix of financial instruments, including repayable ones, can be considered more mature. On the other hand, markets that rely solely or mainly on grants can be considered less mature. This simple division is pictured in Figure 42, where the EU average is used as reference point. The percentage of grant-based instruments and the corresponding share of grants that are open to rollout-phase (i.e., mature) projects are provided for each Member State in the Table 7.

The use of equity, quasi-equity or guarantees is not preferable to that of grants and loans *per se*. Further, it should be taken into account that bank loans represent the main source of external finance for firms in the EU, while equity and bonds are rarely used, as reported by EIBIS[176]. However, the availability of only grants and loans is not likely to address the range of investment needs and barriers faced by the H&C sector at different stages of development.

Figure 42: Share of grants in EU firms' financing mix (all sectors, all sizes). EU average was indicated as a reference point for distinguishing between less and more mature markets.



Source: EIBIS

For the purpose of this study, we have calculated the **percentage of grant instruments for ready to build projects** (rollout-stage technologies) for each Member State. A high value for this indicator can be interpreted as a sign of low market maturity (see Figure 41)

[176] European Investment Bank Investment Survey, 2021, available at: Link

Summary table on comprehensiveness and diversity of financial instruments

The Table 7 provides a summary of all the indicators introduced in this section:

- HHI as a measure of diversity ranging from 0 (perfect diversity) to 10,000 (one single type of instruments)
- Percentage of grants for rollout-stage technologies ranging from 0% (none of the mapped grants target mature technologies) to 100% (all of the mapped grants fund mature technologies)

Table 7: Comprehensiveness and diversity of financial instruments for heating and cooling

Country	Concentration Index (HHI)	Grants for rollout as a % of grant instruments
Austria	1488	50%
Belgium	3554	40%
Bulgaria	5185	50%
Croatia	4394	100%
Cyprus	10000	N/A
Czechia	4848	71%
Denmark	5102	75%
Estonia	4700	100%
Finland	5000	N/A
France	3314	N/A
Germany	6913	24%
Greece	4286	75%
Hungary	3418	N/A
Ireland	5800	50%
Italy	5408	N/A
Latvia	5432	100%
Lithuania	1901	50%
Luxembourg	4815	60%
Malta	3471	60%
Netherlands	5762	N/A
Poland	9932	100%
Portugal	4000	100%
Romania	4219	N/A
Slovakia	8300	100%
Slovenia	10000	N/A
Spain	8025	100%
Sweden	8889	N/A

Countries with "N/A" are countries without any mapped grant schemes or whose grants do not specify if they are open to mature technologies or not.

How to read the data – examples of countries:

- **Spain** shows a limited diversity of financing instruments for heating and cooling, with a high share of grant-based instruments. These grants are entirely directed to mature technologies funding (although not necessarily exclusive to mature technologies).
- On the other hand, **Austria** and **Lithuania** exhibit a wide variety of financing instruments for heating and cooling, including a moderate share of grants, which could be understood as a sign of more mature markets. Half of these grants target mature technologies.
- Finally, regarding **Finland**, the diversity of instruments for heating and cooling is rather limited, but none of the grants fund mature technologies.

Summary of findings on market maturity

The Table 8 combines all the indicators presented in the previous sections with information about the RES in H&C gaps for each Member State based on the information presented in Section 2. The Member States have been ranked from 1 to 27 for each indictor, where 1 is the best and 27 is the worst. For indicators for which some Member States do not have data, i.e., GB market, public investments, and share of grants, the scoring is on a smaller range.

Table 8: Summary of findings on market maturity per country

Member State	RES in H&C 2021-2030 GAP (in %)	Market maturity					Availability of instruments	
		Debt and loans of corporates	Stock market capitalisation	Green Bonds Market	Public investments in RES	WACC	Concentration Index (HHI)	Grants for rollout as a % of grant instruments
Austria	4.1	7	16	12	9	9	1	3
Belgium	3.3	19	8	10	11	8	6	2
Bulgaria	11.3	14	19	N/A	8	15	16	3
Croatia	4.7	22	18	N/A	14	21	10	7
Cyprus	7.5	15	25	N/A	21	25	26	N/A
Czechia	10	23	1	19	15	22	13	5
Denmark	6	4	3	5	17	4	15	6
Estonia	7.7	8	23	21	N/A	14	11	7
Finland	7	10	5	6	13	7	14	N/A
France	12	9	6	4	7	6	3	N/A
Germany	8.2	12	10	7	4	1	21	1
Greece	12.4	27	15	15	19	24	9	6
Hungary	10.5	3	22	13	16	26	4	N/A
Ireland	16.2	24	14	11	18	10	20	3
Italy	13	21	12	14	6	19	17	N/A
Latvia	4.2	26	26	17	22	13	18	7
Lithuania	16.3	11	24	16	23	12	2	3
Luxembourg	16.8	1	9	1	N/A	3	12	4

Member State	RES in H&C 2021-2030 GAP (in %)	Market maturity					Availability of instruments	
		Debt and loans of corporates	Stock market capitalisation	Green Bonds Market	Public investments in RES	WACC	Concentration Index (HHI)	Grants for rollout as a % of grant instruments
Malta	3.7	6	17	N/A	24	11	5	4
Netherlands	5.2	5	4	3	10	2	19	N/A
Poland	11	17	11	18	2	23	25	7
Portugal	4	16	13	9	3	16	7	7
Romania	7.8	18	20	23	1	27	8	N/A
Slovakia	8.1	13	27	22	20	17	23	7
Slovenia	5	20	21	20	N/A	20	27	N/A
Spain	13	25	7	8	5	18	22	7
Sweden	3	2	2	2	12	5	24	N/A

Note: WACC depends on central bank policy that determines risk free rate. It relates to the countries with no EUR. Central bank policy is to decrease inflation so countries with high inflation have higher WACC.

Interpretation of the results at Member State level

The complex picture of indicators presented in Table 9 does not always present a clear-cut conclusion regarding the state of market maturity for the financing of heating and cooling, but nevertheless can lay the ground for some general findings at country level.

As can be seen from the following Table 9, it is possible to group the EU Member States based on the size of their RES in H&C gap (understood as the difference between the share of RES in H&C planned for 2030 and the share in 2020[177]), the degree of market maturity and the extent to which the current offering of financial instruments is relevant given the criteria considered above (calculated as average of the rankings presented in the Table 8 above). The interpretation is provided per group in the following paragraphs.

Table 9: Grouping of countries by market maturity and RES in H&C gap

	High market maturity	Medium maturity	Low market maturity
Small RES in H&C gap	Austria, Netherlands, Sweden, Belgium	Portugal, Malta	Croatia, Latvia, Slovenia
Medium RES in H&C gap	Denmark, Finland, Germany	Czechia, Estonia, Hungary	Cyprus, Romania, Slovakia
Large RES in H&C gap	Luxembourg, France	Bulgaria, Italy, Ireland, Poland, Spain	Greece, Lithuania

Note: Countries coloured in green are considered to have a relevant offering of financial instruments, whereas those in red have some room for improvement.

Countries with high market maturity and:

- **Small RES in H&C gap – Sweden** is positioned favourably in terms of fulfilling its ambitious 2030 targets of over 72% of the energy it uses in H&C from renewable sources, as it faces relatively minor gaps to bridge. This can be attributed to the country's access to a broad range of private capital sources, which provides ample opportunities for funding. Additionally, despite a limited availability of financial instruments, the heating and cooling sector in Sweden benefits from a comparatively low WACC, likely due to the appealing debt options offered by private financial entities. **Austria** and **the Netherlands** are in a similar position, although with more modest 2030 targets. Austria displays a good offering of financial instruments, whereas the Netherlands relies mostly on loans and could use a wider deployment of blended schemes and guarantees. **Belgium** also has a good offering of financial instruments, although it is the country with the lowest target share of RES in H&C, only 11.3% by 2030.

- **Medium RES in H&C gap – Denmark, Finland,** and **Germany** are in a very similar situation of high market maturity, moderate investments in renewable energy and medium sized-gap in RES in H&C. Similarly, all three countries could benefit from a more diversified offering of financial support schemes. In Denmark and Finland there are only loan and grant schemes, perhaps as a direct effect of having a mature market that does not require extensive public support. In Germany, there are also predominately loan and grant instruments, with one available guarantee scheme.

[177] Gaps in RES in H&C were classified as "small" if the gap is below 6%, over 6 and below 11 was considered as "medium", whereas over 11 was classified as "large".

- **Large RES in H&C gap – Luxembourg** and **France** stand out for displaying a rather diversified offering of financial instruments, although none of them present blended instruments. Luxembourg is the country with the largest RES in H&C gap in the EU, at 16.8%, but given its market maturity it should be well positioned to achieve the planned 2030 RES share in H&C.

Countries with <u>medium market maturity</u> and:

- **Small RES in H&C gap – Portugal** and **Malta** both show a rather small gap, despite having quite different 2030 targets (38% and 25.8%, respectively). Both countries have a rather diversified offering of financial instruments for H&C. The offering in Portugal is comprised only of grants and loans and there could be better targeting of the available grants towards innovative technologies. In Malta, there are also some guarantee and technical assistance schemes that could help the country achieve its 2030 targets.

- **Medium RES in H&C gap – Czechia** enjoys a good stock market capitalisation and high public investments in renewable energy. However, the use of grants for mature technologies could be improved and technical assistance schemes could be deployed. The offering in **Estonia** is characterised by a good number of equity schemes and could also benefit from the introduction of technical assistance facilities. Hungary ranks first in terms of public investments in energy and has a good offering of financial instruments, although it suffers from a very high WACC.

- **Large RES in H&C gap – Bulgaria**, **Italy**, **Ireland**, **Poland**, **Spain** have similar RES in H&C gaps ranging from 11% (Poland) to 16.2% (Ireland), despite having very different 2030 targets. Bulgaria has good levels of public investments in energy and a strategic use of grants. To achieve its ambitious 2030 target, the country could benefit from a wider use of blended schemes, guarantees and technical assistance. Italy relies only on loans and grants, and could thus also use a more diversified offering for H&C. In Ireland, there is a combination of grants, loans, equity, guarantee and technical assistance, although loans and grants represent the largest share of instruments available. Poland is the country with the highest number of mapped instruments for H&C which are, however, mostly concentrated in loans and blended schemes. In Spain, there are only grants, with the exception of one loan scheme, with all instruments open to rollout solutions. A more targeted use of grants could be recommended and as well as the introduction of more “sophisticated” financial instruments, such as blended schemes and guarantees.

Countries with <u>low market maturity</u> and:

- **Small RES in H&C gap** – **Croatia** has a RES in H&C gap of 4.7 and a rather diversified offering of financial instruments, although loans represent more than half of available instruments and all grants are open for mature technologies. **Latvia** presents a similar situation, although the financial instruments landscape is slightly more concentrated. In **Slovenia,** there are only loans and one grant. The country could benefit from a more varied provision of financial instruments. Given the low market maturity, blended schemes with a grant component and a repayable one could prove to be successful.

- **Medium RES in H&C gap –** In **Cyprus,** the mapping identified only grant instruments for H&C. This, in combination with high WACC and low public investments in renewable energy could prove to be a challenge for the country to reach its 2030 target of RES share in the heating energy usage. **Romania** has a slightly more diversified offering of financial instruments, which consists mostly of grants and loans, but also cases of equity and quasi-equity. Furthermore, the country also has good levels of public investments in renewable energy, which benefit also the H&C sector. The focus in **Slovakia** is mostly on loans when it comes to H&C financial instruments, although examples of equity, grants and guarantees are also present. However, a more targeted use of grants could prove to be beneficial and prevent a crowding out effect.

- **Large RES in H&C gap – Greece** has a moderately diversified offering of financial instruments, spread across loans, grants, equity, blended finance, guarantee and technical assistance. However, high cost of capital, the small green bond market and overall unfavourable availability of finance might represent a challenge for the country when it comes to investment in H&C. **Lithuania** shows a very diversified offering of financial instruments, with only blended schemes missing, and a medium WACC. However, the country also has the second largest RES in H&C gap, at 16.3%, and a rather low track record of public investments in renewable energy.

6. Findings and recommendations

6.1. Summary of findings

A large step up in financing will be needed for Member States to achieve Fit for 55 and REPowerEU targets and objectives. To do so, national decarbonisation strategies for heating and cooling must include significant energy conservation measures and speed up the phase out from fossil fuels.

Financial instruments can address some of the barriers to investment for heating and cooling. Different technologies have different financing needs, depending on their maturity and the barriers they are facing. For emerging technologies, availability and access to finance remain a key risk next to the inherent technology risks. For mature technologies, regulatory and policy risk as well as administrative barriers are key.

A mapping of financial instruments at Member State level resulted in data on 300 instruments available to support heating and cooling in the 27 EU Member States. Among these 300, loans and grants are the most popular instruments across the EU. **A total amount of around €126 billion has been estimated to be available inter alia for heating and cooling projects**. However, while only twelve schemes only support heating and cooling, most schemes target at least one more energy segment, and 171 schemes target all segments of the energy value chain. Consequently, only around €50 billion are channelled through H&C-only instruments.

Most of the mapped instruments target mature and market-ready projects, with SMEs and larger companies being the most targeted category of beneficiaries. In the context of H&C, households and public sector entities also receive support by mapped instruments due to the increased number of campaigns launched by Member States over the last years to incentivize cleaner residential H&C applications.

Across Member States, different levels of market maturity persist. In countries where the market for Renewable Energy Sources in the Heating and Cooling sector is still developing and there is a significant investment gap to meet their 2030 targets, the availability of a wide range of financial instruments is critical[178]. For instance, according to Eurostat [133] countries like Ireland, the Netherlands, and Belgium have been identified as having the lowest shares of renewable sources for heating and cooling. These countries could benefit from such financial instruments to boost their renewable energy sector and close the investment gap. The EU has established mechanisms to support renewable energy projects, encouraging a greater uptake of renewable energy sources across the EU[179]. These mechanisms[180] can be particularly beneficial for countries with a limited market and substantial investment gap.

Four primary factors have been identified as crucial for a support scheme to be effective in the heating and cooling sector: 1) aggregating multiple projects to create more attractive ticket sizes for investors, 2) a streamlined application process available throughout the year, 3) lower bureaucratic demands, and 4) sustained long-term support.

First, encouraging the **aggregation of multiple heating and cooling projects** is vital to attain appealing investment sizes for institutional investors. This strategy addresses the challenge posed by a mismatch between supply and demand of financing, especially when individual project sizes are deemed too small to attract significant investment. Leveraging municipalities and ESCOs as aggregators, along with combining different financing types in larger projects, facilitates risk reduction and enhances the attractiveness of the portfolio.

[178] Renewables steadily increasing in heating and cooling - Products Eurostat News - Eurostat (europa.eu) Link

[179] Support schemes for renewable energy (europa.eu) Link

[180] EU renewable energy financing mechanism - European Commission (europa.eu) Link

Second, **facilitating an easy and accessible application process** is crucial for encouraging participation in support schemes. This involves simplifying application and implementation processes to reduce potential deterrence for participants. Allowing applications to be submitted year-round, rather than during specific periods, adds flexibility and increases the likelihood of participation in the support scheme. This streamlined approach ensures efficient and continuous engagement in the funding process.

Third, streamlining financial instruments with **low bureaucratic requirements** is crucial to expedite investments in the heating and cooling sector. A technology-neutral and sector-agnostic instrument profile simplifies processes and broadens the scope, making financial instruments more accessible and applicable to various technologies, sectors, and project sizes. Ensuring a broad and flexible scope for these instruments enhances their effectiveness in supporting diverse energy investments.

Fourth, and finally, emphasizing **long-term support** in planning is essential for mobilizing private capital for DHC projects. This includes conducting comprehensive national-level mapping to understand potential investment structures and ensuring stability in financial instruments. Long-term visibility and predictability are critical for project promoters to plan business and financial models effectively, fostering investor trust and incentivizing engagement.

Implementing these recommendations will contribute to the creation of an effective support scheme in the heating and cooling sector, addressing financing challenges and encouraging investment in sustainable solutions.

6.2. Recommendations and next steps

Based on the analysis conducted, it was possible to broadly identify the direction in which the next generation of financial support schemes for heating and cooling should move towards:

- In regulated markets (such as Austria, Finland), municipalities and municipality-owned companies encounter hurdles in accessing external debt or engaging in share sales to raise funds for H&C projects due to regulatory constraints. Limitations in regulatory frameworks often limit financing options to state budget allocations or tariffs paid by end-users, since the asset owners cannot give up ownership or incur in debt. Consequently, investments in sustainable and efficient district heating primarily rely on increased public spending and revisions in tariff systems. Exploring ways to adapt regulatory frameworks to facilitate private capital involvement could be a pivotal direction. **Successful models in countries like the Netherlands, Sweden, and the UK, which effectively leveraged private capital for DHC, underscore the importance of regulatory environments that encourage private investments.** Moving forward, the direction should aim to create regulatory frameworks that enable a diverse array of financing options. Embracing private capital, whether through privately-owned ventures or public-private partnerships, can offer a more robust mix of public and private financing sources.

- In markets more open to private participation and private financing, **governments should leverage the resources provided by programmes such as the Recovery and Resilience Facility and the Modernisation Fund** to foster the upgrade and the construction of sustainable and efficient district heating and cooling systems. In more regulated markets, **regulatory authorities and legislators should review current tariff regimes** to ensure DHC operators' revenues are sufficient to cover their expenses and have sufficient margins to invest in refurbishment of older systems and construction of new ones if needed. However, this revision of the tariff schemes should not put an unduly financial burden on end users, as this would increase citizens opposition to sustainable and efficient district heating.

  - **Concession contracts** are an available option for DHC, whereby public authorities outsource a certain proportion of the business (or its construction) to a private company. WG members agreed that concessions could represent an attractive way of financing both the construction and maintenance/upgrade of current DHC infrastructure. However, this model is not suited for emerging technologies and might result in being very complex from an administrative point of view.
  - **Energy communities** are also another option for DHC. Energy communities are voluntary legal entities established at a local level[181]. Energy communities organise collective and citizen-driven energy actions that contribute to increasing public acceptance of renewable energy projects and make it easier to attract private investments in the clean energy transition. This extends also to the construction, expansion and modernisation of heat networks, and are sometimes referred to in this case as "thermal energy communities". In this scenario, individual households and corporates would group together and collectively finance H&C interventions through, for instance, direct equity to a Special Purpose Vehicle in charge of the H&C project[182].

- Heat Pumps projects are usually smaller in scale and financed at an individual level, both for households and companies. When compared with the replaced fossil fuel alternative, they can be as much as three times more capital intensive. The large upfront cost required for purchase and installation of a heat pump is the main barrier for this kind of investments. There is an overall need to increase the provision of incentives and financing for the replacement and installation of new heat pumps.
  - When it comes to **households**, measures should mostly consist of awareness raising campaigns and loans combined with grant or interest rate subsidy components. For certain types of households, such as those with lower incomes or in social housing, grants and other types of subsidies could be used more generously.
  - For **industrial heat pumps**, loans and tax incentives should be preferred over disbursable grants, so as to reduce the impact on public finances while still incentivising the installation of new industrial heat pumps. Accelerated depreciation schedules were also indicated by WG members as a viable option.

  Working Group members are currently working with the European Commission, DG ENER, to scope and define the features and characteristics of a possible financial instrument component of the **Heat Pump Accelerator** under the Heat Pump Action Plan[183].

- **Countries with low availability of diverse financial instruments and less mature financial markets would benefit from targeted efforts to develop and expand the offering of schemes for heating and cooling** to progressively reduce their reliance on grants and combine them with repayable instruments. WG members noted in particular that private equity tends be the most suitable form of equity for H&C projects that are usually a good fit for mid-mature stage portfolios and require long term investors and long-term performance. However, WG members also pointed out that grants should not be completely phased out, as they still represent an important and useful tool to support district heating operators, particularly smaller ones, in facing capital-intensive decarbonisation investments, which might otherwise be delayed or cancelled.

[181] European Commission (2019). Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU.

[182] TEMPO DHC. Crowdfunding as a novel financial tool for district heating projects Link

[183] European Commission. Heat pumps – action plan to accelerate roll-out across the EU Link

- **Technical assistance services are needed for all stakeholders in the heating and cooling sector** (companies, investors, and public authorities), and should thus be deployed more broadly, particularly in countries with low market maturity and for which there is a limited knowledge of H&C.
- **The mapping covered mainly instruments targeting mature technologies, while EU programmes like the Innovation Fund and – especially - Horizon Europe have financed innovative heating and cooling projects** based on mid heat sources such as geothermal and waste heat**.** WG members stressed the need to have an **ongoing support** through the long development phase which characterizes H&C solutions, since in the field only mature and tested technologies can be effectively deployed.

The accelerated deployment of electric heat pumps, both as part of district heating systems and individual ones, will contribute to a rapid increase in demand for electricity. Meeting this increase in demand would require a substantial increase in investment in the energy production and transmission and distribution networks. **The findings and recommendations of this Study should, therefore, be read and considered together with the findings and recommendations from the other Studies produced in the context of the Investors Dialogue on Energy.**

- Bibliography

A Clean Planet for all A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy, *European Commission*, Brussels 2018

https://ec.europa.eu/clima/system/files/2018-11/com_2018_733_analysis_in_support_en.pdf

An EU-wide assessment of National Energy and Climate Plans Driving forward the green transition and promoting economic recovery through integrated energy and climate planning, *European Commission*, Brussels 2020

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0564&from=EN

Barriers and best practices for wind and solar electricity in the EU27 and UK, *eclareon GmbH*, March 2022

https://www.eclareon.com/sites/default/files/res_policy_monitoring_database_final_report_01_0.pdf

Bhandari, K., P., Collier, J., M., Ellingson, R., J., Apul, D., S., Energy payback time (EPBT) and energy return on energy invested (EROI) of solar photovoltaic systems: A systematic review and meta-analysis, 2015

https://www.sciencedirect.com/science/article/abs/pii/S136403211500146X

Breaking Down Investment Barriers at Ground Level - Case studies and other evidence related to investment barriers under the third pillar of the Investment Plan for Europe, *European Investment Bank*, *European Investment Fund*, 2016

https://www.eib.org/en/publications/breaking-down-investment-barriers-at-ground-level

Broken promises: Legal recourse for retroactive FIT cuts, *PvMagazine.com*, January 2020

https://www.pv-magazine.com/2020/01/23/broken-promises-legal-recourse-for-retroactive-fit-cuts/

Carvalho, R., Hittinger, E., Williams, E., Payback of natural gas turbines: A retrospective analysis with implications for decarbonizing grids, 2021

https://www.sciencedirect.com/science/article/abs/pii/S0957178721001417#:~:text=Using%20historical%20data%2C%20we%20find,types%20of%20fossil%20fuel%20infrastructure.

Combination of financial instruments and grants under shared management funds in the 2021-2027 programming period, *fi-compass factsheet,* May 2021
Combination of financial instruments and grants (fi-compass.eu)

Data insight: The permitting problem for EU wind farms, *Energy Monitor*, April 2022

https://www.energymonitor.ai/policy/data-insight-the-permitting-problem-for-eu-wind-farms
Developing an Effective State Clean Energy Program: Renewable Energy Incentives, *Clean Energy States Alliance,* 2009
https://www.cesa.org/wp-content/uploads/CESA-renewable-energy-incentives-mar09.pdf

Decarbonising heating and cooling — a climate imperative — European Environment Agency (europa.eu), Apr 2023

https://www.eea.europa.eu/publications/decarbonisation-heating-and-cooling/decarbonising-heating-and-cooling

El ICO lanza al mercado su cuarto bono verde por importe de 500 millones de euros para financiar proyectos sostenibles de compañías españolas, *ICO*, May 2022 https://www.ico.es/el-ico-lanza-al-mercado-su-cuarto-bono-verde-por-importe-de-500-millones-de-euros-para-financiar-proyectos-sostenibles-de-compa%C3%B1%C3%ADas-espa%C3%B1olas

El MITECO apoya 45 proyectos de comunidades energéticas impulsados por más de 2.600 personas, pymes y entidades locales, *IDAE*, June 2022

https://www.idae.es/noticias/el-miteco-apoya-45-proyectos-de-comunidades-energeticas-impulsados-por-mas-de-2600

Energy efficiency targets, *European Commission*

https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-targets_en

Energy Technology Perspectives 2020, *International Energy Agency*, 2020

https://iea.blob.core.windows.net/assets/7f8aed40-89af-4348-be19-c8a67df0b9ea/Energy_Technology_Perspectives_2020_PDF.pdf

EU electricity market rules must support renewables investments, *WindEurope*, April 2022

https://windeurope.org/newsroom/press-releases/eu-electricity-market-rules-must-support-renewables-investments/

Europe's building only half the wind energy it needs for the Green Deal, supply chain is struggling as a result, *WindEurope*, February 2022

https://windeurope.org/newsroom/press-releases/europes-building-only-half-the-wind-energy-it-needs-for-the-green-deal-supply-chain-is-struggling-as-a-result/

Ex-ante assessment methodology for financial instruments in the 2014-2020 programming period, *fi-compass*, May 2014
https://ec.europa.eu/regional_policy/sources/thefunds/fin_inst/pdf/ex_ante_vol5.pdf

Ex post evaluation of EIB Intermediated lending to SMEs in the EU, 2005-2011 https://www.eib.org/attachments/ev/ev_synthesis_report_smes_en.pdf

Final Report – Cost of Energy (LCOE): Energy costs, taxes and the impact of government interventions on

Investments, *Publications Office of the European Union*, Luxembourg 2020

https://op.europa.eu/en/publication-detail/-/publication/76c57f2f-174c-11eb-b57e-01aa75ed71a1/language-en

Financial instruments under the European Structural and Investment Funds: Summaries of the data on the progress made in financing and implementing the financial instruments for the programming period 2014-2020 in accordance with Article 46 of Regulation (EU) No 1303/2013 of the European Parliament and of the Council Situation as at 31 December 2020

https://ec.europa.eu/regional_policy/sources/thefunds/fin_inst/pdf/summary_data_fi_1420_2020.pdf

Gas grid operators unveil plan for European hydrogen infrastructure 'backbone', *Euractiv.com*, July 2020

https://www.euractiv.com/section/energy/news/gas-grid-operators-unveil-plan-for-european-hydrogen-infrastructure-backbone/

General Block Exemption Regulation (GBER)

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02014R0651-20210801&from=EN

German wind energy stalls amid public resistance and regulatory hurdles, *DW.com*, September 2019

https://www.dw.com/en/german-wind-energy-stalls-amid-public-resistance-and-regulatory-hurdles/a-50280676

Global Trends in Renewable Energy Investment 2020, *Frankfurt School-UNEP Center*, 2020

https://wedocs.unep.org/handle/20.500.11822/32700?show=full

Guidelines on State aid for climate, Environmental protection and energy (CEEAG)

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022XC0218(03)&from=EN

Greece: EIB first Recovery and Resilience Facility transaction backs a €524million landmark project with Greece's Independent Power Transmission Operator to connect the Western and Southern Cyclades islands to mainland electrical grid, *EIB,* 2023

Green energy: Insuring a renewables future, *Allianz*, July 2019

https://www.agcs.allianz.com/news-and-insights/expert-risk-articles/green-energy-Insuring-a-renewables-future.html

Italy: FIEE SGR gets EU backing to close its second fund dedicated to energy efficiency, *EIB*, August 2020

https://www.eib.org/en/press/all/2020-219-fiee-sgr-gets-eu-backing-to-close-its-second-fund-dedicated-to-energy-efficiency

Italy introduces 11-month retroactive incentive cut on PV systems over 20 kW, *PvMagazine.com*, January 2022

https://www.pv-magazine.com/2022/01/28/italy-introduces-11-month-retroactive-incentive-cut-on-pv-systems-over-20-kw/

Ireland: €240 million financing facility secured by solar developer Power Capital Renewable Energy from an Eiffel Investment Group led set of investors to construct over 1.2 GW of solar assets and expand internationally, *EIB,* 2023
https://www.eib.org/en/press/all/2023-006-eur240000000-financing-facility-secured-by-irish-solar-developer-power-capital-renewable-energy-from-an-eiffel-investment-group-led-set-of-investors-to-construct-over-1-2-gw-of-solar-assets-in-ireland-and-expand-internationally

KfW domestic promotional programmes for energy efficiency: Key elements and success factors, *KfW,* 2020
http://jaspersnetwork.org/download/attachments/26411157/Dominik%20Bach.pdf?version=1&modificationDate=1600072079000&api=v2

Kost, C., Shammugam, S., Fluri, V., Peper, D., Memar, A., D., Schlegl, T., Levelized Cost of Electricity Renewable Energy Technologies, *Fraunhofer Institute*, June 2021

LearnWind: WindEurope launches educational hub to tackle skills gap, *WindEurope,* September 2021

https://windeurope.org/newsroom/press-releases/learnwind-windeurope-launches-educational-hub-to-tackle-skills-gap/

Only three successful applicants for zero-interest climate loans since 2017, *RTL Today,* 2021
RTL Today - Energy efficiency programme: Only three successful applicants for zero-interest climate loans since 2017

Oroschakoff. K., Guàrdia, A., B., Europe's stranded assets: Mapped, Politico.eu, June 2020

https://www.politico.eu/article/stranded-assets-europe-mapped-energy-climate/

Pacifico Energy Partners and Eiffel Investment Group join forces to develop photovoltaic plants and battery energy storage systems in Europe, *Pacifico Energy,* 2022 https://www.pacifico-energy.com/pacifico-energy-partners-pacifico-and-eiffel-investment-groupeiffel-join-forces-to-develop-photovoltaic-plants-and-battery-energy-storage-systems-in-europe/

Projected Costs of Generating Electricity, *IEA*, 2020

https://www.iea.org/reports/projected-costs-of-generating-electricity-2020

Press Release UBI Banca closes the first Green Bond issue on the wholesale market Orders close to €1.5 billion, 3 times the amount of the issue

https://group.intesasanpaolo.com/content/dam/portalgroup/repository-documenti/sostenibilt%C3%A0/inglese/green-bond-ubi/UBI%20Banca_3%20april%202019%20def_press%20release.pdf

Rapid assessment of the EIB Group's operational response to the COVID-19 crisis

https://www.eib.org/attachments/publications/rapid_assessment_covid_reponse_en.pdf

RENAISSANCE survey on renewable energy and community solutions, *RENAISSANCE project*, 2020

https://www.renaissance-h2020.eu/renaissance-survey-on-renewable-energies-and-community-solutions/

Renewable energy: Why institutional investors are finally bullish, *Capital Monitor*, 2021

https://capitalmonitor.ai/institution/asset-owners/renewable-energy-why-institutional-investors-are-finally-bullish/

REPowerEU: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition, *European Commission*, May 2022

https://ec.europa.eu/commission/presscorner/detail/en/IP_22_3131

Retroactive cuts for solar feed-in tariffs, *Dentons.com*, November 2020

https://www.dentons.com/en/insights/alerts/2020/november/26/retroactive-cuts-for-solar-feed-in-tariffs

Risks associated with new technology on renewable energy projects, *Freshfields Bruckhaus Deringer*, March 2022

https://sustainability.freshfields.com/post/102hjty/risks-associated-with-new-technology-on-renewable-energy-projects

Synthesis on the Plant-Level Cost of Nuclear: Workshop on Cost Electricity Generation, *OECD-NEA*, January 2016, Paris

https://www.oecd-nea.org/upload/docs/application/pdf/2020-07/fulll_cost_workshop_5._synthesis_on_the_plant-level_cost_of_nuclear.pdf

Sendstad L.H., Hagspiel V., Jebsen Mikkelsen W., Ravndal R., Tveitstøl M., The impact of subsidy retraction on European renewable energy investments, *Department of Industrial Economics & Technology Management, Norwegian University of Science & Technology*, 2022

https://www.sciencedirect.com/science/article/pii/S0301421521005401#:~:text=In%20the%20same%20line%20of,also%20impacted%20by%20policy%20changes.

Stepping up Europe's 2030 climate ambition. Investing in a climate-neutral future for the benefit of our people*, European Commission*, SWD (176), Brussels 2020

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020SC0176

Still great interest in funding for green energy projects, *EUDP*, March 2022 https://www.eudp.dk/en/nyheder/stadig-stor-interesse-stoette-til-groenne-energiprojekter

Stranded assets and renewables: how the energy transition affects the value of energy reserves, buildings and capital stock, International Renewable Energy Agency (IRENA), Abu Dhabi, 2017

file:///C:/Users/rlupascu00/Downloads/IRENA_REmap_Stranded_assets_and_renewables_2017.pdf

Study providing analytical support for the financial instruments and programmes to facilitate investment in the energy sector: the Recovery and Resilience Facility, *European Commission*, 2022

Technical assistance: Local authorities needs and upcoming policy, *Build Upon,* 2021

https://www.bpie.eu/wp-content/uploads/2021/12/BU_TA_0112.pdf

The Greentech Fund Call 2022/09 received a total of six applications, *SmartCap,* 2023

The Greentech Fund Call 2022/09 received a total of six applications - SmartCap

Treaty on the Functioning of the European Union (TEFU)

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:12012E/TXT&from=EN

UK energy titan SSE says low wind, driest conditions in 70 years hit renewable generation, *CNBC.com*, September 2021

https://www.cnbc.com/2021/09/29/sse-says-low-wind-dry-conditions-hit-renewable-energy-generation.html

Unlocking banks' capacity to fund the recovery, *European Stability Mechanism,* 2022

https://www.esm.europa.eu/blog/unlocking-banks-capacity-fund-recovery

Wind Turbine Payback Period, *Enerpower*, 2011

https://enerpower.ie/2011/03/30/wind-turbine-payback-period/

What you need to know about the skills shortage threatening the UK offshore wind industry, *K2Management*, December 2021 https://www.k2management.com/news/skills-challenges-offshore

Why extreme weather is putting renewable systems in the spotlight, *Energy Monitor*, 2021

https://www.energymonitor.ai/policy/market-design/why-extreme-weather-is-putting-renewable-systems-in-the-spotlight

- Annexes

Annex 1: Definitions of instruments used for the mapping

Loan

A loan is an agreement which obliges the lender to make available to the borrower an agreed sum of money for an agreed period of time and under which the borrower is obliged to repay that amount within the agreed time[184]. In case of a loan provided or guaranteed by a public authority, directly or indirectly, it can help addressing a shortage of finance available where commercial banks are unwilling to lend on acceptable terms to the borrower. Nonetheless, commercial banks can also provide loans at better conditions than normal market ones as part of their lending strategy without public support (e.g., as in the case of loans for solar panels installation for which a strong pipeline is foreseen).

A financial instrument in the form of loan can be either provided directly by commercial banks at better conditions than what they would apply in a standard commercial loan (following the market interest rate), or directly by a public (regional, national, or European) body. In the case, for instance, of a guaranteed loan, the bank usually shares the risks it takes with a public authority, which functions as guarantor and financer, and allows the bank to take a greater degree of risk exposure and provide higher amounts of financing than it would be able to do in normal conditions. In the second case, the public authority directly provides the loan and acts as financial institution.

In the case of a public authority, the repayments of the loan allow the so-called revolving effect, that is the situation where the flows of money coming from the repayment of the loan is invested in another loan.

Loans play an important role in the European economy, constituting on average over 50% (56.2%) of the external finance of European companies[185].

Equity

An equity investment is the provision of capital to a company, invested directly or indirectly in return for total or partial ownership of that firm and where the equity investor may assume some management control of the firm and may share the firm's profits. In the case of equity, the financial return depends on the growth and profitability of the company and is earnt through dividends and/or the sale of the shares to another investor[186].

Equity constitutes around 0.5% of EU companies' external finance[187].

Quasi-equity

A type of financing that ranks between equity and debt, having a higher risk than senior debt and a lower risk than common equity. Quasi-equity investments can be structured as debt, typically unsecured and subordinated and in some cases convertible into equity, or as preferred equity.

Grants

Direct financial contributions provided to third-party beneficiaries (i.e., companies and households). This contribution does not need to be paid back and is usually aimed at covering part of the upfront costs (CAPEX) or of the operating costs (OPEX) of a project. Grants can

[184] European Commission (2015). Guidance for Member States on Financial instruments – Glossary.

[185] EIB Investment Survey 2021.

[186] Fi-compass.

[187] EIB Investment Survey 2021.

also be used to cover the costs of technical assistance to companies to conduct energy audits, develop bankable projects, etc.

On average, grants represent 9.16% of EU companies' external financing[188].

Bonds

Bonds are a fixed-income instrument that represents a loan made by an investor to a borrower. In return for the loan, the bond issuer will pay interest to the bondholder at fixed intervals until the bond matures and the money is paid back. Bonds can be issued by companies or by public entities.

According to the EIB Investment Survey 2021, bonds account for around 1% of EU companies' external financing composition[189].

Blended finance

Blended finance is the combination of finance from public and private resources to finance projects. Blended finance can be distinguished from other types of financial instruments by the fact that it requires a combination of public and private resources to implement a certain project jointly by the public and private sector.

Like financial instruments, blended finance is used to achieve public policy objectives that, in the existing market conditions, cannot be achieved through pure market dynamics and/or legislation.

Guarantees

A guarantee is a written commitment to assume the responsibility for all or part of a third party's debt, usually a commercial bank's, if an event such as a loan default occurs[190]. The guarantor, which can be a public institution, disburses resources only if the guaranteed fails to comply with its commitments.

For final beneficiaries (i.e., companies and households), guarantees take the form of a loan, as the guarantee is always provided to a financial intermediary, a bank or a fund, for instance, which then provides financing at better conditions.

Technical assistance

TA refers to different types of services provided to final beneficiaries and/or financial intermediaries to improve their capacities/skills to, for instance, perform business modelling, financial planning, risk assessment, report, etc.

Technical assistance (TA) is essential for the successful deployment of financial support instruments and for the achievement of their objectives and goals. Know-how transfer and capacity building can provide benefits to all stakeholders involved in an energy generation project. On the one hand, TA can be developed to help project promoters preparing a solid business and financial plan that is ready to be submitted to investors and financial institutions, and thus **improve the investment readiness** of projects and **their ability to access external financing options**. Combining technical assistance with instruments such as loans or grants can therefore facilitate the implementation and uptake of such instruments to support well-defined and more mature project proposals.

TA can also help project promoters comply with the different requirements, for instance, in terms of reporting. This can be particularly helpful for start-ups and SMEs, which might lack dedicated personnel to comply with the requirements or might simply not have the knowledge/expertise to do so. On the other hand, TA can also be useful for investors, banks, and other financial institutions to adequately understand how some sectors and types of

[188] EIB Investment Survey 2021.

[189] EIB Investment Survey 2021.

[190] European Commission (2015). Guidance for Member States on Financial instruments – Glossary.

project work, how they are structured, and how revenues are generated. This type of TA is sometimes used in market development programmes for new emerging sectors (e.g. blue economy, cybersecurity, etc.). Investors are usually not familiar with emerging sectors and tend to refrain from investing in them due to their lack of awareness of potential revenues, and to the lack of know-how on how to screen opportunities and identify and quantify risks. Finally, TA can also help policymakers, regulatory, and local authorities to better grasp the technicalities and specificities of a given market sector so as to be able to write informed and tailored legislation, regulation, and public procurement.

Annex 2: Overview of EU financing programmes for Heating & Cooling

Energy in the MFF and NGEU	Aim	Specific Funding sectors (if any)	Total Budget
	Main energy-relevant programmes		
Connecting Europe Facility - Energy (CEF Energy)	Supports investments in building new cross-border energy infrastructure in Europe or rehabilitating and upgrading the existing one.	**(1)** Energy Infrastructure projects (PCIs) **(2)** Cross border Renewable Energy projects	€ 5.84 billion
LIFE Programme	The LIFE Programme is the EU's funding instrument for the environment and climate action.	**(1)** Nature and biodiversity **(2)** Circular Economy and Quality of Life **(3)** Climate Change Mitigation and Adaptation **(4)** Clean Energy Transition	€ 5.43 billion
	of which Clean Energy sub-programme		
InvestEU Programme	The InvestEU Programme supports sustainable investment, innovation and job creation in Europe. It aims to trigger more than €372 billion in additional investment over the period 2021-27.	**(1)** Sustainable Infrastructure **(2)** Research, Innovation and Digitalisation **(3)** SMEs **(4)** Social Investment and Skills	€26.2 billion
Horizon Europe	Horizon Europe is the EU's key funding programme for research and innovation which tackles climate change, helps to achieve the UN's Sustainable Development Goals and boosts the EU's competitiveness and growth.	Focus on research and innovation.	€ 95.5 billion
European Regional Development Fund (ERDF)	The European Regional Development Fund (ERDF) aims to strengthen economic, social and territorial cohesion in the European Union by correcting imbalances between its regions.	**(1)** Competitiveness **(2)** Low carbon resilience **(3)** connected: enhancing mobility **(4)** inclusive employment and skills **(5)** locally led development and sustainable urban development	€ 370 billion
Cohesion Fund	The Cohesion Fund provides support to Member States with a gross national income (GNI) per capita below 90% EU-27 average to strengthen the economic, social and territorial cohesion of the EU.	The Cohesion Fund supports investments in the field of environment and trans-European networks in the area if transport infrastructure (TEN-T).	

Energy in the MFF and NGEU	Aim	Specific Funding sectors (if any)	Total Budget
Just Transition Mechanism (Just Transition Fund and Public Loan Facility)	**The Just Transition Fund** supports the economic diversification and reconversion of the territories concerned. It focuses on: investments in Small and Medium-sized Enterprises, creation of new firms, research and innovation, environmental rehabilitation, clean energy, up- and reskilling of workers, job-search assistance, transformation of existing carbon-intensive installations **The Public Sector Loan Facility (PSLF)** is the third pillar of the Just Transition Mechanism. It supports projects addressing the challenges deriving from the transition to the European Union's climate target objectives in the territories most negatively affected by the climate transition as identified in the previously approved Territorial Just Transition Plans.		**Just Transition Fund:** € 19.32 billion, of which € 10.87 is under NextgenerationEU **PSLF**: €1.525 billion
Recovery and Resilience Facility (RRF)	The aim of the Recovery and Resilience Facility is to mitigate the economic and social impact of the coronavirus pandemic and make European economies and societies more sustainable, resilient and better prepared for the challenges and opportunities of the green and digital transitions.		€ 723.8 billion
Other programmes that might benefit energy			
Instrument for pre-accession Assistance (IPA)	The IPA acts on 5 components • Assistance for transition and institution building; • Cross-border cooperation (with EU Member States and other countries eligible for IPA); • Regional development (transport, environment, regional and economic development); • Human resources (strengthening human capital and combating exclusion); • Rural development.		€ 14.162 billion
non-MFF/NGEU programmes			

Energy in the MFF and NGEU	Aim	Specific Funding sectors (if any)	Total Budget
Innovation Fund	The Innovation Fund will contribute to greenhouse gas reduction. It is designed to take into account the lessons learned from its predecessor, the NER300 programme. It focuses on highly innovative technologies and big flagship projects with European value added that can bring significant emission reductions.	Focus on Innovative technologies	€ 25 billion
Modernisation Fund	The Modernisation Fund is a dedicated funding programme to support 10 lower-income EU Member States in their transition to climate neutrality by helping to modernise their energy systems and improve energy efficiency.	**(1)** Generation and use of energy from renewable sources **(2)** Energy efficiency **(3)** Energy storage **(4)** Modernisation of energy networks, including district heating, pipelines and grids **(5)** Just transition in carbon-dependent regions	€ 48 billion (depending on carbon price)

Annex 3: Methodology for WACC Calculation

We have calculated the Weighted Average Cost of Capital (WACC) for Renewable Energy projects in Europe, using the following formula:

$$WACC = \frac{D}{D+E} * CoD * (1-t) + \frac{E}{D+E} * CoE$$

Where:

- *D* is the market value of a firm's debt
- *E* is the market value of a firm's equity
- *t* is the corporate tax rate
- *CoD* is the cost of debt after tax, calculated as follows: $CoD = (risk\ free\ rate + sector\ specific\ spread) * (1 - t)$

  We have applied a +2% assumption for lenders' margins to risk free rate and the sector specific spread, based on the literature on energy finance[191]. We have selected the country specific risk-free rate to reflect country risks[192].

- *CoE* is the cost of equity, calculated as follows: $CoE = risk\ free +\ \beta * ERP$, where ERP is the equity risk premium of every country and β is a measure of the volatility — or systematic risk — of a security or portfolio (or a specific sector/transaction) compared to the market as a whole. ERP is country-specific and β is specific to the renewable energy sector. Both data are extracted from Aswath Damodaran (Stern, New York University)[193].

One note on $\frac{D}{D+E}$ and $\frac{E}{D+E}$. They are specific to the renewable energy sector, reflecting the levels of debt and equity normally used for renewable energy projects. However, in absence of country-specific data, we have assumed that these variables are the same across the whole EU. This is of course an important caveat, as differences in $\frac{D}{D+E}$ and $\frac{E}{D+E}$ across countries might exist and they would significantly affect the WACC.

The Table 10 shows the calculation of the WACC for each country.

[191] Source: IRENA, RENEWABLE POWER GENERATION COSTS IN 2021, available at: https://www.irena.org/publications/2022/Jul/Renewable-Power-Generation-Costs-in-2021#:~:text=The%20global%20weighted%20average%20levelised,%25%20to%20USD%200.075%2FkWh.

[192] Source: Statista, available at: https://www.statista.com/statistics/885915/average-risk-free-rate-europe/ https://www.statista.com/statistics/885915/average-risk-free-rate-europe/

[193] Available at: https://pages.stern.nyu.edu/~adamodar/New_Home_Page/datacurrent.html

Table 10: WACC calculation for each Member State

Country	ERP - Total Equity Risk Premium	Country Risk Premium	Beta - Green & Renewable Energy	Risk free (Nov-2022)	CoE - Cost of Equity	Tax rate	E/(D+E)	D/(D+E)	CoD - After Tax Cost of Debt	WACC
Austria	6.57%	0.56%	0.87	1.80%	7.51%	25%	67.48%	32.52%	2.85%	5.77%
Belgium	6.85%	0.84%	0.87	1.40%	7.36%	25%	67.48%	32.52%	2.55%	5.59%
Bulgaria	8.24%	2.23%	0.87	1.60%	8.77%	10%	67.48%	32.52%	3.24%	6.87%
Croatia	9.51%	3.50%	0.87	1.50%	9.77%	18%	67.48%	32.52%	2.87%	7.36%
Cyprus	9.51%	3.50%	0.87	3.50%	11.77%	13%	67.48%	32.52%	4.81%	9.31%
Czechia	6.85%	0.84%	0.87	4.10%	10.06%	19%	67.48%	32.52%	4.94%	8.09%
Denmark	6.01%	0.00%	0.87	1.40%	6.63%	22%	67.48%	32.52%	2.65%	5.15%
Estonia	7.00%	0.99%	0.87	2.50%	8.59%	20%	67.48%	32.52%	3.60%	6.73%
Finland	6.57%	0.56%	0.87	1.40%	7.11%	20%	67.48%	32.52%	2.72%	5.51%
France	6.70%	0.69%	0.87	1.30%	7.13%	27%	67.48%	32.52%	2.43%	5.39%
Germany	6.01%	0.00%	0.87	1.20%	6.43%	30%	67.48%	32.52%	2.24%	4.85%
Greece	11.04%	5.03%	0.87	1.60%	11.20%	24%	67.48%	32.52%	2.74%	8.24%
Hungary	8.67%	2.66%	0.87	4.90%	12.44%	9%	67.48%	32.52%	6.28%	10.26%
Ireland	7.00%	0.99%	0.87	1.50%	7.59%	13%	67.48%	32.52%	3.06%	5.99%
Italy	9.08%	3.07%	0.87	1.70%	9.60%	24%	67.48%	32.52%	2.81%	7.17%
Latvia	7.69%	1.68%	0.87	2.00%	8.69%	20%	67.48%	32.52%	3.20%	6.69%
Lithuania	7.19%	1.18%	0.87	2.00%	8.26%	15%	67.48%	32.52%	3.40%	6.51%
Luxembourg	6.01%	0.00%	0.87	1.40%	6.63%	25%	67.48%	32.52%	2.55%	5.10%
Malta	7.19%	1.18%	0.87	2.00%	8.26%	35%	67.48%	32.52%	2.60%	6.12%
Netherlands	6.01%	0.00%	0.87	1.30%	6.53%	25%	67.48%	32.52%	2.48%	5.01%
Poland	7.19%	1.18%	0.87	4.00%	10.26%	19%	67.48%	32.52%	4.86%	8.20%
Portugal	8.67%	2.66%	0.87	1.60%	9.14%	21%	67.48%	32.52%	2.84%	6.90%
Romania	9.08%	3.07%	0.87	7.20%	15.10%	16%	67.48%	32.52%	7.73%	12.30%
Slovakia	7.19%	1.18%	0.87	2.70%	8.96%	21%	67.48%	32.52%	3.71%	7.00%
Slovenia	7.69%	1.68%	0.87	2.60%	9.29%	19%	67.48%	32.52%	3.73%	7.25%
Spain	8.24%	2.23%	0.87	2.10%	9.27%	25%	67.48%	32.52%	3.08%	7.01%
Sweden	6.01%	0.00%	0.87	1.40%	6.63%	21%	67.48%	32.52%	2.70%	5.17%

MJ-05-23-566-EN-N

ISBN 978-92-68-10996-0

Publications Office
of the European Union