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Promotion of e-mobility through buildings policy

Final Report

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Directorate-General for Energy
Directorate B — Just Transition, Consumers, Energy Efficiency and Innovation
Unit B3 — Buildings and Products

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Table of Contents

List of tables

List of figures

ABSTRACT

This study aims to identify lessons learned from existing legislative and non-legislative measures, including the Energy Performance of Buildings Directive (EPBD), to support the integration of e-mobility infrastructure into the EU building stock and promote the use of EVs. It includes a review of the e-market and its impact on recharging points in buildings **(Chapter II)**. This chapter compares the need for recharging infrastructure in buildings if the EU's decarbonisation targets are to be met, with what is expected to be delivered through the policy measures outlined in the proposed amendments to the EPBD. It also compares the impacts of the current EPBD and the EPBD proposal on the deployment of recharging infrastructure in 2030 and 2050. The analysis of legal and policy measures **(Chapter III)** provides an overview of the transposition of the provisions of Article 8 of the EPBD in the 27 EU Member States (EU-27) and their reflection in the legislation of Norway, Iceland, and the United Kingdom (UK). It identifies additional national legal measures on e-mobility in buildings not linked to the EPBD and details the different barriers, good practices, incentives related to the deployment of recharging infrastructure in Member States **(Chapter IV)**. Finally, based on the above and on several consultations with stakeholders a shortlist of six policy options was developed **(Chapter V)** to accelerate recharging infrastructure deployment in buildings, facilitate the process of deploying recharging infrastructure, and to ensure the future proofing of recharging installations.

EXECUTIVE SUMMARY

This study was commissioned by the European Commission's Directorate-General for Energy (DG ENER) and carried out between January and August 2022 during the negotiation of the recast Energy Performance of Buildings Directive (EPBD). It aims to identify lessons that can be learned from existing legislative and non-legislative measures, including the EPBD, to support the integration of electromobility (e-mobility) infrastructure into the European Union (EU) building stock and promote the use of electric vehicles (EVs). The lessons and conclusions from this study will support the development of future policy by complementing and reinforcing the information gathered in the context of the Impact Assessment for the recast EPBD. They will also inform the Commission in the preparation of its reporting to the European Parliament and the Council on the potential contribution of a Union building policy to the promotion of e-mobility, which is due by 1 January 2023.

The study includes **a review of the e-market and its impact on recharging points in buildings.** It compares the need for recharging infrastructure in buildings if the EU's decarbonisation targets are to be met, with what is expected to be delivered through the policy measures outlined in the proposed amendments to the EPBD. It concludes that the EPBD proposal entails sufficient pre-cabling to meet the long-term demand for recharging infrastructure in the multi-family buildings affected by the proposed EPBD measures. For new and renovated office buildings, the number of recharging points supplied by the EPBD proposal is estimated to be above 2030 demand but below 2050 demand. For existing offices, the supply of recharging points is estimated to be below 2030 demand, with the gap increasing towards 2050. For other non-residential buildings, there are no significant differences between 2030 supply and demand, but for 2050, a surplus of pre-cabled parking spaces is expected in new and renovated other non-residential buildings, with a shortage of recharging points in those existing buildings. It identifies possible gaps between supply and demand based on differences between regions and types of buildings, in particular between rural and urban areas and different types of non-residential buildings (excluding offices). Finally, it highlights that limited implementation of the Renovation Wave Strategy risks excluding a significant proportion of buildings from the EPBD, limiting its impact on the e-mobility market (e.g. non-implementation of the Renovation Wave would mean 1.1 million fewer parking spaces equipped with pre-cabling in residential buildings in 2030, as well as 0.7 million fewer parking spaces equipped with recharging points in non-residential buildings).

This review also compares the impacts of the current EPBD and the EPBD proposal on the deployment of recharging infrastructure in 2030 and 2050. It estimates that the EPBD proposal would ensure that 3.6 million parking spaces in residential buildings are provided with pre-cabling in 2030, compared to 2.4 million parking spaces provided with ducting infrastructure under the current Directive. This estimate increases to 29 million parking spaces in 2050, compared to 19 million under the current Directive. For non-residential buildings, the EPBD proposal is expected to bring more changes. Whereas under the current EPBD, there are projected to be 2.6 million parking spaces with recharging points and 1.8 million with ducting infrastructure by 2030, projections under the EPBD proposal are 7.1 million parking spaces with recharging points and 9 million with pre-cabling. In 2050, the EPBD proposal is expected to provide non-residential buildings with 16 million recharging points and 74 million pre-cabled parking spaces, compared to 5 million recharging points and 15 million parking spaces with ducting infrastructure under the current Directive. The impact on offices is particularly significant, with the EPBD proposal providing four times more recharging points in offices than the current EPBD, and twice as many in other non-residential buildings.

The analysis of legal and policy measures provides an overview of the transposition of the provisions of Article 8 of the EPBD in the 27 EU Member States (EU-27) and their reflection in the legislation of Norway, Iceland and the United Kingdom (UK). It identifies additional national legal measures on e-mobility in buildings not linked to the EPBD. It concludes that Article 8 was transposed 'a minima' in the majority of Member States, with few Member States adopting more stringent measures in respect of parking space thresholds triggering recharging points and/or ducting infrastructure obligations and/or recharging points and ducting infrastructure (e.g. higher rate/number of charging points per parking spaces, specific requirements on types of charger and capacity, pre-cabling requirements). It identifies additional e-mobility requirements in buildings not linked to the EPBD, primarily fire safety measures and bicycle parking spaces. It stresses that the UK is the only country that requires recharging points in buildings to have smart recharging functionality. A set of **barriers to the deployment of recharging infrastructure in Member States were** identified:

- Obligation to have the consent/agreement of landlord/co-owners for the installation of recharging points;
- Complex and/or lengthy authorisation and permitting procedures for the installation of recharging points;
- Lack of clarity (or absence) of legal obligations;
- Lack of adequate checks or enforcement;
- Limited requirements for existing buildings;
- Lack of requirements for heavy-duty vehicles (HDVs);
- Excessive fire safety requirements in underground parking of buildings;
- Extension of the public distribution grids inside building parking spaces (bloc flexibility);
- Lack of requirements for smart charger installations;
- Prohibition on attaching cables to chargers in buildings;
- Prohibition on installing type-2 recharging points in buildings with public access;
- Insufficient load centre capacity;
- Insufficient generation and distribution capacity;
- Shortage of qualified technicians to install and maintain recharging points;
- Competition for available parking spaces;
- Lack of data on housing stock and parking spaces;
- High costs for existing buildings;
- High costs for developers in relation to perceived commercial advantage;
- Poor management of public grants for infrastructure;
- Recharging infrastructure mainly installed where business case already exists;
- Lack of business case for installation of recharging points in commercial sites, due to specific load demands;

The following **opportunities and good practices** were also identified:

- Application of the 'right to plug' (e.g. at own expense of person making request, notification instead of approval, refusal only possible in specified set of circumstance);
- Facilitation of co-owner decisions by enabling approval by simple majority instead of absolute majority, for example;

- Simplified planning and permission procedures by exempting recharging infrastructure from planning permission;
- Provision of guidance, information and model agreements to the relevant parties; training of real estate professionals;
- Pre-financing of collective infrastructure.

The study developed **a shortlist of six policy options** to accelerate recharging infrastructure deployment in buildings, facilitate the process of deploying recharging infrastructure, and ensure the future proofing of recharging installations. These six options were developed based on several criteria:

- Respond to one or several of the end goals and barriers identified;
- Suitable to be adopted (although they may be further detailed and/or adapted) in an EU directive context - more precisely, in the framework of this study, within the EV charging infrastructure provisions of the EPBD (i.e. policies more suitable for adoption at national or local level, through non-binding guidelines or another form of legal text, were not selected);
- European Commission and stakeholder feedback and priorities gathered throughout the study.

This led to this final shortlist of policy options:

1) In non-residential buildings, differentiate EPBD provisions by user profile of parking facilities (Article 12(1) and Article 12(2) EPBD recast).
2) Implement reporting requirements on the number and nature of recharging infrastructure deployed in all buildings falling under the provisions of Article 12 of the EPBD recast.
3) Strengthen the provisions requiring pre-cabling and implement provisions mandating recharging point implementation in new residential buildings and residential buildings undergoing major renovations (Article 12(4) EPBD recast).
4) Eliminate or revise the exemptions under Article 8(6)c and Article 8(4) of the EPBD from 2018.
5) As part of Article 12(8) of the EPBD recast, include provisions requiring Member States to implement single national/local one-stop-shops (e.g. institutional entity, website) for process and legal guidance and assistance for in-building charging infrastructure deployment for owners, tenants and users of parking spaces in buildings.
6) Adopt Article 12(6) of the EPBD recast (‘Member States shall ensure that […] recharging points […] are capable of smart charging, and where appropriate, bi-directional charging’).

1 INTRODUCTION TO THE STUDY

1.1 EU legal and policy context on e-mobility in buildings

The enhancement and application of the Energy Performance of Buildings Directive (EPBD) as a lever to manage the nexus between building and transport energy policy has been identified by EU decision-makers as an important component of the EU's strategy to decarbonise the economy and meet its greenhouse gas (GHG) emissions reductions targets. Several factors will affect the rate of adoption of electric vehicles (EVs), including their affordability, convenience, and reliability compared to traditional internal combustion engine (ICE) vehicles. Ease of access and characteristics of EV recharging infrastructure has a bearing on these factors, but also has wider consequences. For example, EV uni-directional (smart) and bi-directional charging capability has significant potential to act as a powerful demand response (DR) tool, which by increasing the flexibility and cost-effectiveness of the electricity system could be a key factor contributing to a higher penetration level of variable renewable electricity generation within the energy mix. Thus, policies that stimulate the adoption of EV charging infrastructure will directly influence the extent to which the transport sector, electricity system and building stock can be decarbonised. However, policy-makers also need to be aware that this is far from the only benefit of measures stimulating the transition to EVs. The most comprehensive epidemiological study into the impact of fossil fuel-related air pollution was recently published1 and found that 18% of global adult deaths (16.8% in Europe) are attributable to air pollution, doubling the estimates of previous findings. In an era when susceptibility to respiratory illnesses may be set to increase due to potentially enduring impacts from the COVID-19 pandemic, it is imperative that the transition to a low/zero-emission vehicle fleet be accelerated. In addition, the transition to EVs would benefit the European Union (EU) by reducing energy dependency and providing greater economic stimulus and local employment, while enhancing EU industrial competitiveness by placing it at the forefront of the global EV transition.

The identification and implementation of optimal pathways to apply building energy policy to stimulate the adoption of EV recharging infrastructure in buildings is thus liable to be a critical component in the mass adoption of EVs, as convenience of recharging is long recognised as one of the principal factors affecting adoption.

Provisions promoting electromobility (e-mobility) in buildings were introduced in Directive (EU) 2018/844 (EPBD)2, which entered into force in July 2018, with a deadline for implementation in Member States by March 2020. Article 8 of the EPBD requires Member States to support the uptake of e-mobility through equipping buildings with recharging points and ducting infrastructure. It includes several obligations for Member States:

- For new non-residential buildings and non-residential buildings undergoing major renovation, with more than 10 parking spaces: installation of at least one recharging point and ducting infrastructure (enabling the later installation of recharging points) for at least one in every five parking spaces;
- For non-residential buildings with more than 20 parking spaces: lay down requirements for the installation of a minimum number of recharging points by 1 January 2025;

[1] Vohra, K., Vodonos, A., Schwartz, J., Marais, E.A., Sulprizio, M.P. and Mickley, L.J., 'Global mortality from outdoor fine particle pollution generated by fossil fuel combustion: Results from GEOS-Chem', Environmental Research, in press, 2021, available at: https://www.sciencedirect.com/science/article/abs/pii/S0013935121000487
[2] Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency.

- For new residential buildings and residential buildings undergoing major renovation, with more than 10 parking spaces: installation of ducting infrastructure for every parking space;
- Simplification of the deployment of recharging points and addressing possible regulatory barriers, including permitting and approval procedures;
- Consideration of the need for coherent policies for buildings, soft and green mobility, and urban planning.

Directive (EU) 2018/844 refers to recharging points and ducting within the meaning of Directive 2014/94/EU of the European Parliament and of the Council (i.e. on the use of an intelligent metering system, technical standards (such as standards for the connector types of recharging points) and user friendliness). The Alternative Fuels Infrastructure (AFIR) proposal[3] provides further provisions for ensuring user-friendliness of recharging infrastructure. This includes provisions on payment options, price transparency and consumer information, non-discriminatory practices, smart recharging, and signposting rules for electricity supply to recharging points. It also provides for common technical specifications for charging points, complementing existing ones.

However, the need for increased ambition has since become clear, particularly in the context of the adoption of the Climate Law[4] in June 2021, setting a binding 55% emissions-reduction target by 2030, and the accompanying 'Fit for 55' package of measures proposed in July 2021 and December 2021. In the open public consultation on the revision of the EPBD, stakeholders stressed the need for better access to private recharging infrastructure and called for more ambitious requirements for multi-unit buildings undergoing major renovation, as well as simplified procedures for the installation of recharging points[5]. They also emphasised the need for a 'right-to-plug' that would enable tenants and co-owners to have access to recharging points at their homes. A survey of experts[6] for the AFIR Directive found that 71% of respondents (55 of 77) supported the view that additional specific measures at EU level are needed to enable deployment of alternative fuels infrastructure in urban and suburban areas. In addition, 61% of respondents to the same survey agreed that all EV users should have a right to request a publicly accessible recharging point near their residence. However, there was a broad range of opinions on any possible implementation of such a requirement, with several respondents pointing to the right to charge, compared to the right for a recharging point, noting that access to fast direct current (DC) recharging could solve issues. The same study noted that discussions of the primary needs of alternative fuels infrastructure is characterised by considerable uncertainty about future market needs and the risk of investing either too much or too little in further development of the network. The light duty vehicle EV market seemed to have least uncertainty among the modes and alternative fuels considered.

A proposal for a revised EPBD was published on 15 December 2021 as part of the 'Fit for 55' package[7]. Article 12 of the EPBD proposal strengthens the provisions on infrastructure for e-mobility, by:

- Lowering the applicability threshold for new non-residential buildings and non-residential buildings undergoing major renovation to five parking spaces (instead of

[3] Proposal for a Regulation of the European Parliament and of the Council on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU of the European Parliament and of the Council.
[4] Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law').
[5] European Commission, Impact Assessment Report Accompanying the Proposal for a Directive of the European Parliament and of the Council on the energy performance of buildings (recast) {COM(2021) 802 final} - {SEC(2021) 430 final}, {SWD(2021) 454 final}, Brussels, 15.12.2021 SWD(2021) 453 final PART 2/4.
[6] https://ec.europa.eu/transport/sites/transport/files/2019-stf-consultation-analysis.pdf
[7] Proposal for a Directive of the European Parliament and of the Council on the energy performance of buildings (recast), COM(2021) 802 final, 2021/0426 (COD).

10), and requiring pre-cabling of parking spaces for each parking space (instead of ducting infrastructure for one in five), enabling subsequent installation of recharging points for EVs;

- Introducing a requirement for at least one recharging point for every two parking spaces in new and renovated office buildings with more than five parking spaces;
- For all non-residential buildings with more than 20 parking spaces, independent of any renovation, installation of at least one recharging point for every 10 parking spaces (instead of letting Member States set a minimum number) by 2027. For buildings owned or occupied by public authorities, requiring pre-cabling in at least half of parking spaces by 2033;
- Requiring at least one bicycle parking space for each car parking space in all relevant non-residential buildings;
- Lowering the threshold of applicability for new residential buildings and residential buildings undergoing major renovations to three parking spaces (instead of 10), and requiring pre-cabling instead of ducting infrastructure, as well as two bicycle parking spaces per dwelling;
- Requiring Member States to remove regulatory barriers to deployment of recharging points in all buildings, in particular residential buildings, such as the need to obtain consent from the landlord or co-owners to install a recharging point for their own use;
- Introducing requirements on smart recharging and, where appropriate, bi-directional recharging;
- Requiring Member States to ensure the availability of technical assistance for building owners and tenants wishing to install recharging points.

1.2 Scope and objectives of the study

This study was commissioned by the European Commission's Directorate-General for Energy (DG ENER) (Contract No ENER/2021/OP/0005 –ENER/B3/2020-608/04/SI2.862720) and carried out by Milieu SRL, together with Panteia and Trinomics, between January and September 2022, during the negotiation of the recast EPBD. Its main aim is to identify lessons from existing legislative and non-legislative measures, including the EPBD, to support the integration of e-mobility infrastructure into the EU building stock and promote the use of EVs. Those lessons and conclusions will support the development of future policy by complementing and reinforcing the information gathered in the context of the Impact Assessment for the recast EPBD. They will also inform the Commission in preparing its reporting to the European Parliament and the Council on the potential contribution of a Union building policy to the promotion of e-mobility, which is due by 1 January 2023.

The specific objectives of the study are to support the European Commission in gaining a better understanding of:

- The current state-of-play: based on available information and focused interviews, identify relevant legislation at EU and Member State level, state of deployment of recharging infrastructure in buildings;
- Existing good practices for the successful promotion of deployment and use of recharging points in buildings. Best practices in non-EU countries such as Norway, or opportunities overlooked, may also be relevant;
- Existing physical, regulatory and practical barriers to swift uptake of recharging points in buildings;

- Lessons: assess the strengths and weaknesses of the market and legislative framework with respect to the deployment of recharging points and ducting infrastructure in buildings, critically assessing the role of the EPBD and related tools;
- Possible future actions: analyse the relevance, feasibility, particular design features and options, cross-relation of market sectors and possible scope of measures at EU level for the promotion of charging points infrastructure in buildings, then select and analyse policy options;
- Stakeholder view: gather the views of different market actors on the current state-of-play and future developments in recharging points in buildings, paying particular attention to obstacles encountered by early EV users.

The study has four complementary and intertwined parts:

1. **Review of the e-mobility market and its impact on recharging points in buildings:** aims to compare the e-mobility market need for recharging infrastructure in buildings in order to meet EU decarbonisation targets, with what is expected to be delivered through the policy measures outlined in the proposed amendment to the EPBD.
2. **Analysis of legal and policy measures on e-mobility in buildings in Member States, Norway and the UK:** provides up-to-date information on current and proposed legal and policy measures in those countries to support the uptake of recharging points in buildings. It provides an overview of how the provisions of Article 8 of the EPBD are transposed or reflected in these countries (e.g. a minima transposition, transposing measures that go beyond the EPDB, use of exemptions) and identifies additional e-mobility measures in buildings not covered by the EPBD.
3. **Identification of barriers and opportunities for the deployment of recharging infrastructure:** based on the country fiches covering all European Economic Area (EEA) countries and the UK, as well as 10 in-depth country studies (DE, ES, FR, FI, LT NL, PT, SE and NO, UK) on installation and use of recharging points in multi-residential and commercial buildings, good regulatory and policy practices to develop EV recharging points in buildings at national, regional and city level, barriers, areas of improvement, and preliminary recommendations on potential EU actions according to national stakeholders. They entailed interviewing a wide range of actors, such as EV users, building owners and managers, construction sector, distribution system operators (DSOs), local authorities/municipalities, and recharging point installers.
4. **Selection and evaluation of policy options** that may be integrated into the recharging infrastructure requirements of the EPBD (Article 12) and that have the potential to address the barriers identified or to enhance the effectiveness and impact of the EPBD in supporting e-mobility.

1.3 Consultations

In addition to interviews at national level in EEA countries and the UK, four meetings were held to collect complementary information and viewpoints and to validate the preliminary findings of the study:

1. Focus group on 5 May 2022 with representatives of EU stakeholders to present preliminary findings of the study on barriers and opportunities for the deployment of recharging infrastructures (led by Milieu).

2. Presentation of preliminary findings at the Working Group Infrastructures of the Platform for Electromobility[8] on 12 May 2022.
3. Competent authorities (CA) EPBD Plenary Meeting from 7-18 May, where Milieu presented the findings on the analysis of legal and policy measures on e-mobility in buildings and on barriers and opportunities for the deployment of recharging infrastructures in Member States.
4. Workshop on 25 May 2022 with representative of EU stakeholders to present the draft policy options for discussion and validation (led by Trinomics).

Throughout the different consultations, the following categories of stakeholders and their representatives/associations at EU level were invited to contribute and provide feedback:

- Charging point manufacturers and installers;
- EV users;
- EV manufacturers;
- Building owners and managers;
- Construction sector;
- DSOs;
- CAs (national, regional, local);
- Research institutes.

[8] The Platform for Electromobility unites 40+ organisations across civil society, industries, cities and all transport modes. Its members are committed to promoting e-mobility and strive to collectively develop solutions to electrify European transport and to promote those solutions to the EU institutions and Member States.

2 REVIEW OF E-MOBILITY MARKET AND ITS IMPACT ON RECHARGING POINTS IN BUILDINGS

Main findings

The short-term impact of the EPBD proposal on recharging infrastructure in multi-family buildings is quite limited (4% of multi-family buildings are affected by the proposed EPBD measures in 2030 and 36% in 2050), The impact of the EPBD proposal on the e-mobility market for non-residential buildings is quite large, however, with 56% of buildings covered by the EPBD proposal in 2030 and 84% in 2050.

For the multi-family buildings affected by the EPBD proposal, sufficient pre-cabling is required under the proposed EPBD measures to meet the long-term demand for recharging infrastructure

For new and renovated office buildings, the number of recharging points supplied by the EPBD proposal is expected to be above 2030 demand, but below 2050 demand. For existing offices, the supply of recharging points is estimated to be below 2030 demand, a gap that is expected to increase towards 2050.

For other non-residential buildings, no significant differences between supply and demand are expected by 2030. However, for 2050, a surplus of pre-cabled parking spaces is expected in new and renovated buildings, with a shortage of recharging points in existing buildings.

By linking the charging infrastructure requirements to the number of parking spaces, the implementation of the EPBD proposal is, in the long term, expected to realise less recharging infrastructure than demand in urban areas, where parking norms per unit floor space are lower. In rural areas, parking norms per unit floor space are higher, thus the reverse effect is anticipated.

Non-residential buildings with a high share of visitors and a low average duration of stay are expected to have a lower demand for recharging infrastructure per parking space.

Limited implementation of the Renovation Strategy may risk the realisation of 33% of pre-cabled parking spaces at residential buildings, and the realisation of 16% of recharging points and 33% of pre-cabled parking spaces at non-residential buildings.

Compared to the EPBD, the EPBD proposal is projected to provide 11 million additional recharging points and 69 million additional parking spaces equipped with pre-cabling in the long-term (by 2050).

This chapter compares the e-mobility market need for recharging infrastructure in buildings in order to meet EU decarbonisation targets, with what is expected to be delivered through the policy measures outlined in the proposed amendment to the EPBD. The scope of the e-mobility market considered here includes electric passenger cars (M1s) and vans (N1s)[9], with an emphasis on battery electric vehicles (BEV) running exclusively on electricity[10]. The time scale

[9] Other EVs such as heavy-duty vehicles, buses, microcars, electric scooters and motorcycles are not considered, as per the Terms of Reference (TOR) for this study. The proposed EPBD is primarily aimed at facilitating the uptake of electric cars (M1s) and electric vans (N1s). Despite being excluded from the study scope, the growing numbers of electric scooters and motorcycles make them important for the EPBD.

[10] As per the TOR, the focus is on BEV, where substantial growth is expected in the near future. The electricity demand per BEV is higher than for plug-in hybrid electric vehicles (PHEV) because of the size of the battery.

of the analysis is from 2020 to 2050, with estimates for 2020[11] and projections for 2025, 2030 and 2050[12]. The chapter provides:

- An overview of recharging possibilities for EVs in buildings;
- Analysis of available recharging points in residential and non-residential buildings and projections for 2025, 2030, 2050;
- Estimates and projections of recharging points in buildings needs and opportunities for the next 5, 10 and 30 years in areas within scope of the EPBD proposal;
- Estimates and projections of the need for the use and energy consumption for recharging points in all buildings and buildings within scope of the EPBD proposal.

2.1 Overview of charging possibilities for EVs in buildings

The market for EVs and EV recharging infrastructure is still in its infancy, with considerable uncertainty about EV users' behaviour and recharging patterns. The same may be said of the policies best suited to facilitate EV market penetration.

This section aims to give a broad overview of the e-mobility market, particularly the recharging possibilities for EVs in buildings. It begins with an overview of the user demand group, describing existing typologies of users' mission profiles and recharging patterns, then analysing the relative importance of the recharging solutions for the different user profiles (section 2.1.1). This provides an understanding of where recharging points are needed and how the EPBD facilitates this need. Section 2.1.2 focuses on the key attributes of suitable charging systems for the user demand group, such as charging power and speed, charging modes, connector types, recharging points in multi-family residential buildings, and ducting infrastructure. The recharging power determines the recharging speed, but is limited by the maximum input speed of electricity of the vehicle. The maximum recharging speed is not a constant, but depends on the battery charge level. Recharging time may therefore be the biggest concern for (inexperienced) future EV drivers. These first two parts provide key assumptions for assessment of the EBPD (section 2.2).

The third part of this section describes the key aspects of smart recharging, which will play an essential part in enabling rapid growth in recharging demand at buildings (section 2.1.3).

2.1.1 User demand groups

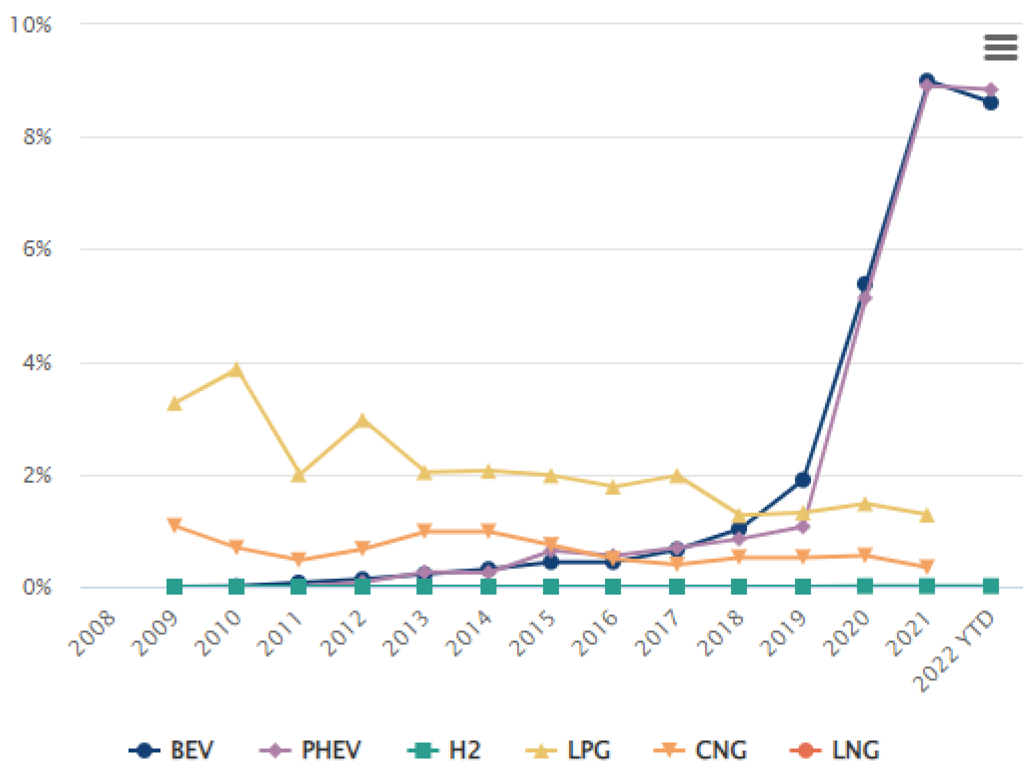
The user demand groups are described based on the users' mission profile and recharging patterns. A distinction is made between the two user demand groups: electric M1 users and electric N1 users. In addition, as the EPBD contains requirements for bicycles, the recharging possibilities for bicycles in buildings are also addressed. ICE two and three-wheelers are not taken into account, as they are currently limited in number, with electric versions of this vehicle category likely to grow strongly in the coming years. This is partly due to the increase in access bans in cities (centres) for all ICE vehicles, including the two and three-wheelers. Several major manufacturers are already planning battery versions that are now beginning to come to market (e.g. Harley Davidson, Triumph, Ducati, Zero, Energica, Vespa).

[11] Data for 2021 may be available from mid-July 2022. Due to sudden disrupting developments in 2021 (particularly COVID-19), the figures for 2021 may differ sharply in trend compared to previous years.
[12] An additional mid-term projection (2040) may be advisable in light of the probable ban on newly produced ICE M1 and N1 vehicles from 2035 onwards.

2.1.2 Passenger cars (M1s)

The first electric M1s were found on European roads as early as 2010, but have significantly increased in numbers only since 2020. In 2018, the total market share of new registrations for BEVs and PHEVs was below 1% in the EU-27, but by 2020 it had increased to 5.4% for BEVs and 5.1% for PHEVs. In 2021, the market share of new sales further increased to 9.0% for BEVs and 8.9% for PHEVs (see Figure 1).

Figure 1: New alternative-fuelled M1 registrations as a percentage of total number of registrations in EU-27



Note: 2022 figures to Q1 only[13].

This growth continued in Q1 2022, with BEVs holding a 10% market share for new registrations, a double that of Q1 2021. It has now overtaken the market share of PHEVs, which in Q1 2022 was 8.9%, about the same level as Q1 2021[14].

The growth of alternative fuel M1s comes at the expense of the market share of petrol and diesel M1s. Although traditional fossil fuel M1s still account for the largest share of new registrations in Q1 2022, at 52.8%, the decline evident in previous years continues, with a 33.2% drop in the share of new sales compared to Q1 2021[15].

By the end of 2021, 2.0 million BEVs and 1.8 million PHEVs were registered in the EU-27, corresponds to 0.84% of the total fleet for BEVs and 0.77% for PHEVs. For comparison, in

[13] https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/european-union-eu27/vehicles-and-fleet

[14] European Automobile Manufacturers' Association (ACEA), New car registrations by fuel type in the European Union, 2022.

[15] ACEA, New car registrations by fuel type in the European Union, 2022.

2018, BEVs and PHEVs accounted for 0.16% and 0.15% of the total passenger M1 fleet, respectively[16].

The growth of the EV market is mainly concentrated in North-Western Europe. Member States with a market share of new registrations of BEVs above 10% are Austria, Denmark, Germany and the Netherlands, with the Netherlands having with the highest share, at 17%. Sweden has the highest share of new registrations in PHEVs, at 23%, followed by Germany, Finland, Denmark and Belgium[17]. In 2021, the highest-selling M1 was a (partly) EV in Switzerland, and in March 2022 in Germany. However, the available statistics typically refer to any 'rechargeable' EV (i.e. both BEV and PHEV)[18].

Sufficient recharging possibilities are needed to facilitate this rapid increase in EV sales. As M1s are often parked next to buildings for extended periods of time, these locations are particularly suitable for recharging infrastructure.

Users' mission profiles and recharging patterns

To understand the need for recharging points in buildings, it is important to identify the user demand groups that would be served by the recharging systems provided under the EPBD. There are various ways of classifying the demand group, such as by recharging pattern[19], degree of EV use[20][21] and recharging location[22,23]. For the EPBD, the most relevant classification is based on the degree of M1 use and the pattern of recharging locations. Previous research identified five user profiles and tehse are described below.

User profile description	
EV owner with a high-end[24] business-leased or corporate-owned M1 *This user uses the EV for commuting and is on the road almost daily for business trips. They also use the M1 for personal daily trips. The user prefers to charge at work because domestic recharging is not commonly reimbursed[25]. However, recharging at home during the night is often necessary to have sufficient driving range for the day ahead. During trips, public fast recharging is mostly used as, according to this user profile, 'time is money'. The user does not mind high recharging costs as they are (nearly always) paid by their employer*	
Type of trips	Mainly business trips
M1 use	Daily, mainly on working days
Average distance	Around 140 km/day on working days (25,000 – 35,000 km per year)[26]

[16] https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/european-union-eu27/vehicles-and-fleet
[17] https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/european-union-eu27/country-comparison
[18] https://insideevs.com/news/582624/europe-plugin-car-sales-march2022/, https://www.jato.com/european-demand-for-bevs-and-phevs-overtakes-diesels-in-march-2022/
[19] Canigueral, M. and Melendez, J., 'Flexibility management of electric vehicles based on user profiles: The Arnhem case study', *Electrical Power and Energy Systems*, Vol. 133, 2021, p. 107195.
[20] Seheon, K., Yang, D., Rasouli, S. and Timmermans, H., 'Heterogeneous hazard model of PEV users charging intervals: Analysis of four year charging transactions data', *Transportation Research Part C: Emerging Technologies*, Vol. 82, 2017, pp. 248-260.
[21] Walton, B., Alberts, G. and Hamilton, J., *Electric vehicles. Setting course for 2030*, Deloitte Insights, 2020.
[22] ACEA, European EV Charging Infrastructure Masterplan, 2022.
[23] Sadeghianpourhamami, N., Refa, N., Strobbe, M. and Develder, C., 'Quantitive analysis of electric vehicle flexibility: A data-driven approach', *International Journal of Electrical Power & Energy Systems*, Vol. 95, 2018, pp. 451-462.
[24] New value (well) above EUR 40,000.
[25] Nevertheless, accounting systems are possible and desirable.
[26] Association of Dutch Vehicle Leasing Companies (VNA), *Vehicle Leasing Market in Figures*, 2020, file:///C:/Users/gramu/Downloads/Autoleasemarkt%20in%20Cijfers%202020%20EN.pdf

User profile description	
Recharging preference	(Semi) fast recharging at work and fast recharging during trips. Regular recharging at home during the night
Recharging costs	Not a decisive criterion, paid by the employer when 'on-duty'. If recharging at home is necessary because of the driving range and the M1 owner receives no compensation, the costs of recharging then play a (limited) role
Examples of users	Sales representatives, real estate agents
Professional EV user with a high-end private or corporate-owned M1 *Driving the M1 around is the main source of income. As there is a close balance between (driving) costs and revenue, recharging costs are important. This user prefers low-cost recharging at (overnight) parking locations, such as depots and fleet hubs, home recharging and public fast recharging during trips if necessary. The EVs are used every day up to their driving range (300-500 kilometres per day)*	
Type of trips	For work purposes
M1 use	Daily (may also include weekend days)
Average distance	Around 200-400 kilometres on working days (50,000-70,000 km per year)[27]
Recharging preference	A taxi driver can usually get through the day on a single charge (large battery), but a (full or) partial refill is usually done during lunch break or while waiting for a new assignment. Unless the taxi driver goes home with their private M1, recharging at parking locations is a fall-back solution if no private parking place is available for overnight recharging
Recharging costs	Low-cost recharging at parking locations and public fast recharging during trips if necessary
Examples of users	Professional drivers, such as taxi drivers and private drivers
Private EV user with a high-end private owned M1 and home recharging opportunity *This user uses the M1 mainly for commuting, a limited number of business trips and leisure trips. They belong to the higher income bracket and generally have a private recharging point at home for overnight recharging. During working hours, the M1 is charged at work if needed. These chargers are mainly low speed, as recharging time is not the main issue. Although this person uses low-cost recharging options, the cost of recharging is not a big issue and they will use public fast chargers if needed*	
Type of trips	Mainly commuting trips and a limited number of business trips and leisure trips
M1 use	Almost daily

[27] Transport & Environment, Europe's giant 'taxi' company: is Uber part of the problem or the solution?, 2021.

User profile description	
Average distance	Around 80 km per day (15,000 – 20,000 km/year)[28]
Recharging preference	Overnight home recharging; public fast charger or work recharging if needed
Recharging costs	Low-cost recharging at home, public fast recharging during trips
Examples of users	Heads of department, senior officials, board members
Private EV user with a low-end or mid-range private owned M1 and no home recharging opportunity, but with a recharging option at work *Charges every day at work because they have no (physical and/or financial) possibility for a private recharging point. This user uses the M1 mainly for commuting and short-distance leisure trips. Uses public recharging or recharging at destinations only in case of issues with the remaining driving range of their battery*	
Type of trips	Commuting and limited number of leisure trips
M1 use	Mainly on working days
Average distance	Less than 70 km per day (around 8,000–16,000 km/year)[29]
Recharging preference	Primarily office location recharging, public fast recharging or recharging at destinations if needed
Recharging costs	During working hours - free or low-cost at the workplace, overnight low-tariff public recharging points
Examples of users	Civil servants, office personnel
Private EV user with a low-end or mid-range private owned M1, with no home and no work recharging opportunities *Has no (physical and/or financial) possibility for an own private charger. User mostly uses other means of transport for commuting, such as public transport and only occasionally uses the M1. The user uses primarily public recharging opportunities. The cost of recharging is important and slower low-cost recharging is preferred. Uses public recharging or recharging at destinations only in case of issues with the remaining driving range of their battery*	
Type of trips	Mainly not work-related trips, such as shopping and leisure
M1 use	A few days per week, mostly at weekends
Average distance	Less than 70 km per day

[28] VNA, Vehicle Leasing Market in Figures, 2020, file:///C:/Users/gramu/Downloads/Autoleasemarkt%20in%20Cijfers%202020%20EN.pdf
[29] Odyssee – Mure, Sectoral Profile – Transport, n.d.

User profile description	
Recharging preference	Overnight recharging at a slow and low-cost public recharging point
Recharging costs	Overnight low-tariff public recharging
Examples of users	Civil servants, office personnel
Private EV user with a low-end or mid-range private owned M1 car, with home recharging opportunities *Has physical and financial possibility for own private charger. This user uses the M1 mainly for commuting and short-distance leisure trips. The user only charges at public recharging stations if the remaining range of the battery requires it*	
Type of trips	Commuting and limited number of leisure trips
Average distance	Approximately 70 km per day on average
Recharging preference	Overnight home recharging and recharging at work (if reimbursed by employer). Only uses public fast charger when the remaining range of battery requires it or work recharging is needed
Recharging costs	Low-tariff slow recharging at home (at work: if reimbursed)

The recharging patterns, i.e. the locations where EV users need and/or prefer to charge, provide an indication of where recharging points are needed. The availability of recharging points at these preferred locations is crucial to facilitate the uptake of EVs. In addition, the recharging speed and costs must reflect users' needs at these locations. In general, there are four types of recharging locations:

- Home recharging;
- Workplace recharging;
- Public recharging;
- Destination recharging.

Home recharging

Recharging at home tends to be the most convenient, cheapest and preferred option for (potential) EV users. However, the main obstacle is the availability of a dedicated off-street parking space at which the recharging point can be mounted. Not every (potential) EV user has access to a private garage or driveway, most notably those living in multi-unit dwellings without the option to install a recharging point without permission from the landlord. The growth of EVs necessitates a solution to this challenge of the availability of sufficient physical space for recharging stations.

EV users make extensive use of home recharging. In Austria, 88% of the recharging of EVs occurs when the user is at home[30]. In the UK, this percentage is estimated at 72.5%[31]. Colle et

[30] Baresch, M. and Moser, S., 'Allocation of e-car charging: Assessing the utilization of charging infrastructure by location', *Transportation Research Part* A, Vol. 124, 2019, pp. 388-395.
[31] Neaimeh, M., Salisbury, S.D., Hill, G.A., Blythe, P.T., Schofield, D.R. and Francfort, J.E., 'Analysing the usage and evidencing

al. (2022)[32] estimate that in 2035, 85% of all recharging points in Europe will be found at home. A slow (3.3kW or 7kW) recharging point is deemed adequate for home recharging, as the M1 is parked at the house for 10 or more hours. In addition, the long dwell times at home offer advantages for flexibility, such as smart recharging and battery storage, and can support peak shaving[33].

Currently, EV use is highest among the socio-demographic group with higher income, higher mileage and higher education[34]. This group generally lives in single-family houses with access to a parking space[35]. As more affordable EV models come onto the market, it is expected that a shift in EV usage will take place in other groups with lower incomes.

The lack of off-street parking at multi-family dwellings can create a shortage of EV recharging at home and thus become a barrier to the uptake of EVs. It is estimated that about half of the EU population lives in multi-family dwellings with limited access to home recharging[36]. This poses a particular challenge in cities, where many residents generally live in this type of housing. In the UK, for example, 70% of households have access to their own off-street parking space, but that figure drops to 30% in urban centres[37]. The recast EPBD addresses the 'right to plug' and some of the challenges associated with residential urban recharging.

'Parking space' versus 'recharging space'

As the share of EVs rises, the difference between a 'parking space' and a 'recharging space' will gain importance. This issue is not only relevant to EV parking spaces near residential buildings, but EV parking spaces near any building. Rules for parking spaces with a recharging station differ from place to place. In rare cases, the only requirement is that the parking space can only be used by EVs, while in others, parking is only allowed when the vehicle is being charged and 'occupancy' charges are applied once the vehicle is charged or after two or three hours of recharging.

Problems may arise when an EV occupies a parking space when the EV user does not need the recharging point, for example when the M1 is already fully charged. Some drivers explicitly slow down the recharging speed in order to occupy the point for longer. Both instances prevent EV users who need the recharging point from accessing it, reducing the efficiency of the recharging point. Some administrations (e.g. Paris) have introduced an occupancy fare to dissuade such behaviour.

This is particularly challenging for parking spaces near buildings. The EV user in the parking space to recharge the vehicle must be at the location, either for living, working or recreation. A parking time limit is inconvenient, requiring the user to interrupt their 'activity' to move the M1 once it is fully charged or when the time limit is reached. This is particularly difficult during the night, for example.

However, when no limit is placed on parking at EV parking spaces, this represents another challenge. Generally, recharging points are found in the most convenient parking spaces in a car park – those located right at the entrance of a building. An EV user may choose to park in an EV parking space because it is conveniently located[38], without needing to charge.

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the importance of fast chargers for the adoption of battery electric vehicles', *Energy Policy*, Vol. 108, 2017, pp. 474-486.
[32] Colle, S., Mortier, T., Micallef, P., Coltelli, M., Horstead, A. and Aveta, M., *Power sector accelerating e-mobility. Can utilities turn EVs into a grid asset?*, 2021.
[33] 'Peak shaving' refers to leveling out peaks in electricity use.
[34] Hoekstra, A. and Refa, N., 'Characteristics of Dutch EV drivers.', EVS 2017 – 30th International Electric Vehicle Symposium and Exhibition, (October), 2017.
[35] Transport & Environment, *How many charge points will Europe and its Member States need in 2020s*, 2020.
[36] Transport & Environment, *How many charge points will Europe and its Member States need in 2020s*, 2020.
[37] Cluzel, C. and Hope-Morley, A., *Transport Energy Infrastructure Roadmap to 2050*, Prepared for the LowCVP by Element Energy Ltd, 2015.
[38] Wolbertus, R. and Gerzon, B., 'Improving electric vehicle charging station efficiency through pricing', *Journal of Advanced Transportation*, 2018.

This effect can be further enhanced by the provision of free parking spaces for EV owners. Although the EV user does not need the recharging point, the user charges the M1 (to a limited extent, or not at all, if recharging is not a requirement for using the parking space) for parking reasons. This prevents other EV users from charging and reduces the efficiency of charge point. Another issue that still needs to be tackled is the abuse of recharging stalls by ICE vehicles. Calling the police to have the vehicle removed or applying a fine takes time and may not be possible.

Solutions include applying a mixed parking/recharging tariff and limiting access with a bar. A stricter and more rigorous enforcement policy is also needed for use/abuse of the limited space available at public loading bays. Alternatively, wide availability of low-power recharging points could mitigate the problem.

Workplace recharging

For EV users without access to home recharging, recharging at the workplace is their preferred solution. Recharging points in these locations are usually slow or medium speed[39] (up to 22kW).

EV users second preference is to recharge at the workplace. In the EU, 15% of all charged energy is charged at the workplace. As EV use increases among people without access to home recharging, the demand for work-related recharging is expected to rise to an estimated 25% in 2030[40].

Some businesses invest in their own recharging network to stimulate electric mobility among their employees. They may also reimburse recharging costs at the workplace to varying degrees, including offering free recharging. This may lead to EV drivers with a recharging point at home preferring to charge at the workplace, due to costs, the absence of a recharging point at home, or because the distance to and from work is too long to cover on one recharging cycle.

Workplace recharging allows for flexible recharging options because M1s are parked there for an extended period of time (up to eight or nine hours on workdays). An additional advantage is that EVs are typically parked near the workplace. Where a workplace is connected to a solar park and has the use of smart recharging, there are opportunities to make use of the (cheap) peak moments of renewable energy generation[41]. This also applies if a public or private recharging station is connected to a source of renewable electricity.

For companies with a commercial vehicle fleet on the road during the day (e.g. e-taxis, e-couriers, electric N1s and electric heavy-duty vehicles (HDVs), recharging at the workplace would mainly take place at night or during lunch breaks. This reduces the possibility of using solar energy, although other renewable sources, such as wind-generated electricity, remain an option. Depending on the size of the fleet, problems may arise with the availability of electricity at times of peak usage (e.g. at night, with no wind).

Public recharging

Although recharging at home and at work are generally cheaper per kWh than public recharging, the latter is certainly necessary. A distinction should be drawn between two essentially different forms of public recharging. The first form concerns public recharging points

[39] See categorisation in the AFIR.
[40] Transport & Environment, How many charge points will Europe and its Member States need in 2020s, 2020.
[41] Fachrizal, R., Shepero, M., Åberg, M. and Munkhammar, J., 'Optimal PV-EV sizing at solar powered workplace charging stations with smart charging schemes considering self-consumption and self-sufficiency balance', *Applied Energy*, Vol. 307, 2022, p. 118139.

with a capacity of up to 22 kW (or 2 x 11 kW). This type of recharging station is mainly found along the underlying (local) road network and is primarily intended for (future) EV owners who do not have the option (or desire) to install their own recharging station. A second, very diverse, user group consists of shoppers or visitors to restaurants, theatres, etc. Compared to fast chargers, the tariff per kWh is relatively low.

The second form of public recharging facilitates longer journeys that exceed battery range and require recharging en route. Most public fast recharging stations are located along national main roads and motorways. As the EV owner has to wait, the recharging speed must be high. This is particularly true for business drivers, where time is money. The recharging capacity of these fast recharging stations is currently 50 kW or more. This lower limit may increase in the coming years as battery capacity and recharging speed (input power) of EVs continues to grow. The rate charged per kWh at these public fast charge points is considerably higher than that charged at local public recharging points.

Destination recharging

Some destinations offer recharging points as convenience recharging while the user is engaged in other activities (e.g. at supermarkets, shopping centres, sports facilities, restaurants, hospitals, hotels). The recharging units are usually for customer/visitor use only and the tariffs are determined by the owner of the recharging units. The (limited) use of these units may be free of charge if they are part of the customer service.

The time spent at a particular destination also influences the recharging profile. The longer the dwell time, the lower the charge capacity can be. Slow recharging is also generally cheaper per kWh. It is therefore cost-optimal to make maximum use of the available recharging time.

For example, in hotels, the guest stays overnight so a slower recharging point (3.3 kW-7.4 kW) is sufficient to completely fill even a large battery of 75-100 kWh at the lowest cost. At supermarkets and shopping centres, customers park for about one-one-and-a-half hours, necessitating a 22 kW[42] capacity recharging point[43].

Recharging needs, by user profile

Combining the user profiles with the recharging profiles suggests the relative importance of recharging solutions. Understanding where each profile would prefer to charge is essential for estimating the need for building recharging infrastructure (section 2.3).

Table 1: Recharging needs for different EV M1 user profiles

Profile	Home recharging	Workplace recharging	Public fast recharging	Public overnight recharging	Destination recharging
1. EV owner with a high-end business-leased or corporate-owned M1	+++		++		++
2. Professional EV user with a high-end private or	(+)	+++	+	(+)	

[42] This 22 kW charge point is often split by using two plugs.
[43] Typically a three-phase recharging point delivering 32 Amps, but frequently the max. power is shared among different points, thus 10 or less kW is available at peak-presence moments.

Profile	Home recharging	Workplace recharging	Public fast recharging	Public overnight recharging	Destination recharging
corporate-owned M1					
3. Private EV user with a high-end private owned M1 and home recharging option	+++	+	+		+
4. Private EV user with a low-end or mid-range private owned M1 and no home recharging option, but with a recharging option at work		+++	(+)	+++	
5. Private EV user with a low-end or mid-range private owned M1, with no home or work recharging options			(+)	+++	+
6. Private EV user with a low-end or mid-range private owned M1, with home recharging option	+++				+

Note: Symbols refer to the energy charged (+ = limited amount, ++ = medium amount, +++ = large amount).

Several observations can be made concerning the recharging of passenger M1s:

1. If the level of recharging costs (in EUR/kWh) is not the main issue, public fast recharging is an option. Otherwise, this recharging option is only be used in case of an ‘emergency’, such as driving on a (nearly) empty battery. PHEVs generally have a DC fast recharging option.
2. In most cases, the cost of recharging the M1 is the main driver of the selection of a certain recharging solution. The most cost-efficient solution is (slow) overnight recharging with a privately owned recharging point at home. If the employer is providing a recharging point, its use depends on how much of the cost is charged to the employee and/or the single trip distance the commuter has to travel.
3. If the employer provides recharging infrastructure and the commuter has only public recharging options, the user can recharge the M1 at the office during working time. In addition, the user can recharge the M1 overnight at a (slow) public recharging point. The balance between the two options depends on a cost comparison and/or the single trip distance between work and home.

4. If there are only public recharging options, the M1 owner prefers to use (slow) public overnight recharging so as to minimise the costs of recharging[44].

The user profiles and recharging patterns are mainly focused on BEVs but also apply to PHEVs. The main difference between the two is that PHEVs have a smaller battery capacity and use an ICE as a backup. The smaller capacity results in the battery being drained more quickly. The availability of an ICE ensures that the PHEV user chooses less opportunistic recharging when the battery is about to run out. PHEV users wait until they arrive at the preferred slow-recharging destination, i.e. at home, at the workplace, or at a public recharging point intended for overnight recharging. Indeed, these recharging locations are the most economical and the user does not have to deal with the extra waiting time for recharging while going to their destination.

The smaller batteries also mean that PHEV users spend less time recharging at the recharging station. As the transition to BEVs and thus to larger batteries takes place in the near future, the utility rate of recharging stations will increase[45].

2.1.2.1 Electric light commercial vehicles (N1s)

Although electric light commercial vehicles (N1s) have been on the market for several years, their market share in the EU has increased considerably only in the last two years, growing from 2.0% in 2020 to 3.0% in 2021. Statistics from ACEA (2022)[46] indicate the extent of its growth and its geographical concentration:

- In 2021, sales of electric light commercial vehicles (BEV and PHEV) in the EU grew by 63.2% compared to 2020, reaching 46,853 electric N1s sold;
- Of the largest EU markets, the biggest increases were in Italy (+238%), followed by the Netherlands (+89%), Spain (+56%), Germany (+45%) and France (+40%);
- In 2021, the market share of electric light commercial vehicles was highest in Sweden (7.6%), followed by Denmark (5.6%), Germany (4.8%), the Netherlands (4.7%), Austria (3.5%) and France (3%);
- High market shares were observed in the rest of Europe, led by Norway (17.0%), followed by Iceland (7.7%), Switzerland (5.2%) and the UK (4.2%).

Electric N1s remain less common than electric M1s, both in absolute numbers and in market penetration. However, their share is expected to increase significantly in the future, in part because, in the short-term, the total cost of ownership (TCO) will favour e-N1s over ICE-N1s[47]. In the near future, more and more European cities are expected to impose restrictions on access to cities for commercial M1s with tail-pipe emissions. Parcel delivery companies and online stores[48] are increasingly advertising their move to electric N1s, and even the installation of PV panels to power their distributions centres and vehicles.

Considering that a large proportion of N1s are charged in buildings, the EPBD plays an important role in enabling the uptake of electric light commercial vehicles and facilitating the greening of freight transport. For e-N1s, approximately 42% of recharging actions take place at the depot, 41% at home, 9% at the customer's premises and 8% on the road[49]. The average

[44] Manufacturers may suggest slow charging in AC as the best option to enhance the battery durability. Charging efficiency is increased, as the faster the recharging, the higher the energy used to cool the battery pack.
[45] Vermeulen, I., Helmus, J.R., Lees, M. and van den Hoed, R., 'Simulation of future electric vehicle charging behavior—effects of transition from PHEV to FEV' *World Electric Vehicle Journal*, Vol. 10, No 2, 2019, p. 42.
[46] ACEA, *New light commercial vehicle registrations by fuel type, European Union*, 2022.
[47] TCO calculations for the Netherlands show that an e-N1 could already break even with a diesel-powered N1 (https://welkeebestelbus.nl/).
[48] https://www.aboutamazon.com/news/transportation/introducing-amazons-first-custom-electric-delivery-vehicle
[49] Top Sector Logistics, Charging infrastructure for electric vehicles in city logistics, 2021.

energy demand of e-N1s is higher than that of electric passenger M1s, due to their higher average annual mileage.

Users' mission profiles and recharging patterns

As electric N1s are used for commercial purposes, they have a different mission profile to M1s and there is a different need for recharging locations. However, there are many similarities with M1s in terms of battery recharging speed and capacity. In general, electric N1s can use the same recharging infrastructure as passenger vehicles. However, because of the (slightly) higher vehicle weights (especially when fully loaded), on average, the battery capacity tends to be somewhat higher than that of electric M1s. This may cause a higher demand for electricity per recharging session.

The number of studies in this field is limited, partly due to the current low market share of e-N1s. The mission profiles described here[50] are drawn from Top Sector Logistics (2021)[51] and Kin et al. (2022)[52] and are categorised into seven sectors. Table 2 describes mission profiles and the recharging patterns for the following sectors:

1. Waste;
2. Buildings logistics;
3. Facilities;
4. Catering;
5. Mail/parcel/courier;
6. Retailers (food);
7. Service logistics.

Table 2: Mission profiles and recharging patterns for electric NI users, by sector

Vehicles	Description
Waste	• Used for municipal cleaning vehicles, often specialised vehicles • Short journeys with high drop density and short stops • Multiple journeys per day, limited to the local level • Almost exclusively depot recharging
Building logistics	• Used for contractors and installation companies • Long stops and limited number of journeys per day • Can be long journeys (regional/local) • N1s mostly stay at home, where they are charged overnight. Recharging points on the road or at customers' premises (if available) are used if needed

[50] Mission profiles for e-N1s are based on case studies carried out in Amsterdam in the Netherlands, which limits their representativeness for European trends. With few studies in this field, however, these are the most detailed studies currently available. The Netherlands has one of the highest market penetration rates of e-N1s in Europe and gives a good indication of where the sector is heading.
[51] Top Sector Logistics, Charging infrastructure for electric vehicles in city logistics, 2021.
[52] Kin, B., Hopman, M. and Quak, H., 'Different charging strategies for electric vehicle fleets in urban freight transport', *Sustainability*, Vol. 13, 2021, p. 13080.

Vehicles	Description
	for longer distances. Generally available at construction sites, where electricity is needed for many other uses
Facilities	• Regional journeys • Multiple journeys per day, with short stops (<30 minutes) when delivering • Overnight recharging at home and at the depot, depending on the type of business. Recharging points on the road or at the customers' premises (if available) are used if needed for longer distances
Catering	• Local journeys • Multiple journeys per day, with short stops (<30 minutes) when delivering • N1s are required to be charged overnight at the depot. Short journeys and short stops do not make it possible or necessary to charge on the road or at customers' premises • Uses refrigerated transport to move perishable goods. These types of N1s have a higher energy demand due to the refrigeration unit. As a result, a larger battery is needed to achieve the same range as normal e-N1s or fast recharging in urban areas, as for mail/parcel delivery or for taxi service
Mail/parcels/courier	• Short journeys with high drop density, short stops and multiple journeys per day • Fixed routes and deliveries at one-off addresses • Recharging at home (overnight) and at the depot (during load time or overnight), depending on the type of business. Short stops do not allow recharging at customers' premises. For longer distances, on-the-road recharging is used, which is used by this sector more than any other sector
Retail (food)	• Several journeys per day • N1s charged overnight at the depot. Short journeys and short stops do not make it possible or necessary to charge on the road or at customers' premises • Similar to the catering sector, this sector sometimes transports perishable goods that require refrigerated transport, thus larger battery or urban fast recharging infrastructure
Service logistics	• Vehicles with a lot of equipment have a high load and high energy demand • Short stops at customers' premises and irregular addresses • Prefers recharging overnight recharging at home or uses on-the-road recharging for longer distances

Recharging needs, by user profile

Combining the user profiles with the recharging profiles shows the relative importance of recharging solutions, as shown in Table 3.

Table 3: Recharging needs for different EV N1 user profiles

Vehicles	Home[53]	By the road	Depot	Customer
Waste			+++	
Building logistics	+++	+		+
Facilities	++	+	++	+
Catering			+++	
Mail/parcels/courier	++	+	++	
Retail (food)			+++	
Service logistics	+++	+	+	

Note: The symbols refer to the frequency of use (+ = rarely, ++ = occasionally/sometimes, +++ = usually).

Several observations can be made concerning the recharging patterns of electric N1s:

- Due to the high average distance driven per day, an e-N1 almost always needs to recharge overnight for the next working day. Opportunity recharging (at the depot or on the road) is necessary for longer daytime journeys;
- E-N1s are only stationary for long periods at night, making smart recharging most suitable for these times;
- Whether the e-N1 user recharges the vehicle at home or at the depot depends on the nature of the business. A courier or catering service, for example, starts their working day at the depot, where they pick up the products for customers. If the N1 is company-owned, it makes more sense to leave the N1 at the depot to recharge overnight. An e-N1 user active in the service logistics sector, such as a plumber or electrician, keeps almost all of the necessary tools in their N1 and can therefore journey to customers from home. Recharging at home is more attractive because it saves a trip to the depot (if there is one);
- The EPBD requirements can prompt businesses reliant on depot recharging to begin investing in an e-N1 - the recharging station is realised and the company's EV fleet increases its utility.

Notwithstanding the positive aspects and attitudes towards the electric N1 market, two major barriers to its full development persist. First, the lack of familiarity with EVs and doubts about the ability to make the same trips with an EV. Second, although there is a break-even TCO with diesel vehicles, the initial investment costs of EVs are about twice that of a comparable diesel N1, although they then have far lower operating costs. For smaller businesses, such as plumbers or market traders, the initial investment may be considered too high.

2.1.2.2 Electrical bicycles

According to the European Commission, the lack of bicycle parking in residential and non-residential buildings is a major barrier to the uptake of cycling. This has led the Commission to

[53] Private off-street or overnight public on-street charging, depending on availability.

include mandatory requirements for the number of bicycle parking spaces in new and majorly renovated buildings in the EPBD.

This section specifically addresses e-bike recharging requirements near buildings. This user group is growing rapidly and their use depends on recharging facilities in buildings. Currently, the EPBD contains no specific requirements for e-bikes.

The e-bike market in Europe has grown in recent years, most notably during the COVID-19 pandemic. Sales of this type of bike increased by 52% between 2019 and 2020[54]. E-bikes represent a growing share of yearly bicycle sales, accounting for 25% of bicycles sold in the EU in 2020. The Netherlands and Belgium lead the e-bike market, where the market share of new sales has reached 50%. By 2030, it is expected that two-thirds of all bicycles sold will be electrically assisted[55]. The number of cargo bikes is also increasing rapidly[56].

In contrast to M1s, e-bikes are typically used for recreational purposes. In the Netherlands, almost 50% of e-bike owners use the bicycle for recreational purposes, followed by home-work trips (24%), and shopping trips (18%).

For the majority of e-bikes sold in the EU, the batteries can be removed from the bike frame. The battery is then charged at home or in the office, using standard 230-volt household power sockets (200-600 kWh batteries are most common for e-bikes), meaning that electrical infrastructure requirements are low.

The majority of users charge their e-bike in their garage (57%), followed by inside the house (31%)[57]. The preference for home recharging is due to the practical difficulties of recharging the battery at destinations. Most of the current public recharging facilities in private areas (e.g. universities) or public areas (e.g. public transport stations) do not supply chargers, as each brand has different chargers. This means that the user must bring the charger, risking it being stolen while the bicycle is being charged. Users prefer to remove the battery – where possible – and take it inside their office or home. As batteries easily weigh 3.5 kg, this is considered uncomfortable. E-bikes therefore require a safe, easy-to-access parking space with access to a standard household power plug. An additional advantage is that these facilities can also be used for other forms of micro-mobility, such as e-scooters and e-steps.

One of the main risks related to e-bike recharging is the lack of relevant regulations and their relationship with possible battery ignitions[58].

In general, it is expected that most e-bike users will recharge their batteries at home. With more alternatives available for recharging e-bikes, the urgency for a dedicated e-bike recharging infrastructure is less than for vehicles. Nevertheless, it is worth considering specific requirements for e-bike power outlets, as normal household power plugs can be used, entailing minimal additional cost and effort. This also contributes to the EU objective of promoting cycling, one of the most climate-responsible forms of mobility. It is important to keep in mind that the bicycle parking space also needs to be secure if it is to be appealing.

2.1.3 Charging systems

From the type of current supplied to the vehicle to the type of connector used, the charging system for EVs comprises different elements and characteristics that, combined, give rise to different performances and applications.

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[54] Confederation of the European Bicycle Industry (CONEBI), European bicycle industry booming, 2021.
[55] European Climate Foundation (ECF), Making buildings fit for cycling by revising the Energy Performance of Buildings Directive, 2021.
[56] Cycle Logistics, European Cargo Bike Industry Survey Results, 2021.
[57] Blauw, Voorbereid op weg met een opgeladen accu, 2019.
[58] According to two interviews with bicycle expert of the Dutch Cycling Embassy.

Many different charging standards, levels, modes, plugs and outlets for EV charging systems are used across the world. This section focuses on the key attributes of charging systems used in Europe[59]. First, the broad categorisation of recharging points used by the AFIR proposal is described, including an overview of the locations of these recharging points. The different charging modes and types for EVs in Europe are then discussed in detail. The final section considers the ducting and pre-cabling infrastructure referred to in the EPBD.

2.1.3.1 Charging power and speed

In the AFIR proposal, Annex III[60], EU recharging points are classified into two broad categories based on their power output and speed. The first category concerns alternate current (AC) charging, while the second concerns DC charging.

Table 4: Recharging point categories in AFIR proposal, Annex III[61]

Category	Sub-category	Maximum power output
Category 1 (AC)	Slow AC recharging point, single-phase	$P < 7.4$ kW
	Medium-speed AC recharging point, triple-phase	$7.4 \text{ kW} \leq P \leq 22$ kW
	Fast AC recharging point, triple-phase	$P > 22$ kW
Category 2 (DC)	Slow DC recharging point	$P < 50$ kW
	Fast DC recharging point	$50 \text{ kW} \leq P < 150$ kW
	Level 1 - Ultra-fast DC recharging point	$150 \text{ kW} \leq P < 350$ kW
	Level 2 - Ultra-fast DC recharging point	$P \geq 350$ kW

EV batteries always require a DC supply for storage, while the current supplied from the mains is AC. Therefore, either the alternating current is transformed in the vehicle itself (AC charging) or this transformation takes place outside the vehicle at the recharging point (DC charging). The charging method used influences the overall design of the charging system and has a direct impact on the maximum power delivered and thus the charging speed[62]. Charging systems with higher capacity (50 kW and upwards) must always be of the DC-type.

AC charging

In AC charging, the vehicle uses its on-board charger to convert the AC to DC. In practice, this means that the maximum power supplied to the vehicle depends on both the electrical specifications of the electrical installation where the EV is charged and the specifications of its built-in AC to DC converter. The domestic electrical installation can be single-phase or three-phase. In Europe, the single-phase voltage is 230 V. The power delivered is proportional to the current (i.e. with a current of 32 A, the load power is 7.36 kW). In the case of three-phase electricity, the voltage in Europe is 400 V (i.e. with a current of 32 A, the charging power is 22

[59] 'Public' charging is out of scope of this section of the study, but within the scope of the AFIR.

[60] Proposal for a regulation of the European Parliament and of the Council on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU of the European Parliament and of the Council, COM(2021) 559, 2021/0223(COD).

[61] Ibid.

[62] Kasten, P., Bracker, J., Haller, M. and Purwanto, J., *Electric mobility in Europe – Future impact on the emissions and the energy systems*, Final report, 2016.

kW). When the on-board charger matches the electrical installation, the power received by the M1 is the same. However, when designing the on-board charger of a vehicle, manufacturers try to make it as light as possible. Therefore, the in-vehicle converter is usually lighter – and thus of lower capacity – than the one installed in a stationary charging station without weight restrictions. More specifically, the on-board charger varies depending on the number of phases it can use (one, two or three) and its power typically ranges from 3.7 kW to 22 kW, with 11 kW most common, and 16-22 kW in premium vehicles. AC charging thus typically involves slower charging speeds. The production, installation and operating costs of AC systems are significantly lower than those required for DC charging, making it a more common method, especially in charging points where EVs are parked for prolonged periods of time[63].

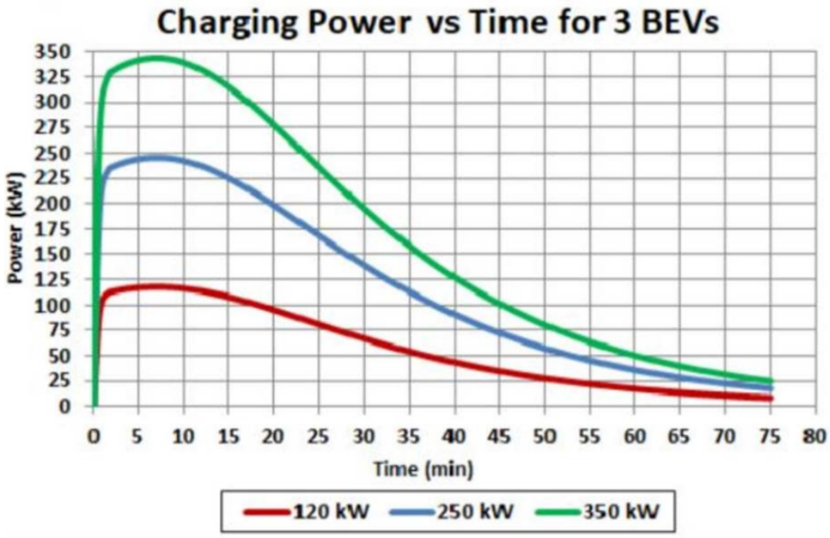
DC charging

In this case, the transformation of AC from the grid into DC takes place at the recharging point. The main benefit is that, as the weight of the converter is no longer a limitation, very high load capacities can be achieved, resulting in very fast charging speeds[64]. However, this technology is many times more expensive than AC charging, so it is more frequently used in recharging areas where vehicles are charged for a short time, such as on a highway[65]. DC chargers typically provide 50 to 150 kW, and the latest charging stations built in Europe can reach 350 kW. Another differentiator between AC and DC charging is the charging curve. For AC, charging the limited capacity of the on-board charger means that it can only receive a limited amount of power, thus its charging curve will decline more steadily over time. By contrast, DC charging takes the form of a degrading charging curve because the EV battery initially accepts a faster flow of energy but gradually decreases as it reaches its maximum capacity. Battery Energy Management Systems (BEMS) and battery cells cannot withstand prolonged recharging at high power, thus as soon as the state of charge (SoC) reaches 40% or 50%, the power is progressively reduced, becoming very limited beyond 80% SoC. For this reason, it is generally not convenient to charge above 80% in DC on long trips, but, rather, to have an extra recharging session.

Figure 2: Charging curves of three EVs with different charging rates but the same battery chemistry presents the charging curves of three EVs with different charging rates (120 kW, 250 kW and 350 kW) but with the same battery chemistry, allowing comparison of their curves. The crucial factor is the integral, i.e. the area below the curve, representing the energy input.

[63] https://newmotion.com/en-gb/support/faq/ac-charging-vs-dc-charging
[64] Kasten, P., Bracker, J., Haller, M. and Purwanto, J., *Electric mobility in Europe – Future impact on the emissions and the energy systems*, Final report, 2016.
[65] https://newmotion.com/en-gb/support/faq/ac-charging-vs-dc-charging

Figure 2: Charging curves of three EVs with different charging rates but the same battery chemistry



Source: InsideEVs, [Battery electric fast charging versus time explained](). n.d.

DC charging is rarely offered in private areas or in buildings, as it is intended for intensive users at public points along motorways or in towns (e.g. taxis, parcel delivery). This may change with the wide adoption of commercial EVs and the forthcoming 'megawatt' recharging points for bus and truck depots[66].

The charging power needed at residential and non-residential buildings depends on the charging strategies of the EV user. Based on the charging patterns of the demand groups for N1s and M1s (section 2.1.1), charging point requirements for different locations can be estimated. This overview is based on ACEA (2022)[67], Colle et al. (2022)[68] and LaMonaca and Ryan (2022)[69].

Table 5: Recharging point requirements, by location and charging power

Maximum power output	Single-family home	Multi-family home	Workplace	Depot[70]	Destinations	Public - slow (overnight)	Public – fast (highway)
< 7.4 kW	+++	+++	++		+++		
7.4 kW - 22 kW	+++	+++	+++	++	+++	+++	
> 22 kW[a]			++	++	++		
< 50 kW[a]			+	++	++		
50 kW - 150			+	++	+		++

[66] https://www.charin.global/technology/mcs/
[67] ACEA, European EV Charging Infrastructure Masterplan, 2022.
[68] Colle, S., Mortier, T., Micallef, P., Coltelli, M., Horstead, A. and Aveta, M., *Power sector accelerating e-mobility. Can utilities turn EVs into a grid asset?, 2021.*
[69] LaMonaca, S. and Ryan, L., 'The state of play in electric vehicle charging services – a review of infrastructure provision, players and policies', *Renewable and sustainable Energy Reviews*, Vol. 154, 2022, p. 111733.
[70] HDVs are beyond the scope of this study, but the depots that use them mainly need higher-capacity DC recharging points.

Maximum power output	Single-family home	Multi-family home	Workplace	Depot[70]	Destinations	Public - slow (overnight)	Public – fast (highway)
kW							
150 kW - 350 kW				+	+		++
P ≥ 350 kW				++[b]			

Note: Symbols refer to how often a charge point can be found at a certain location (+ = rarely, ++ = occasionally, +++ = often); a) These are unlikely scenarios because this type of recharging point is not widely used; b) Nearly exclusively used for charging high-power batteries (200 kWh and upward) of HDVs and (public) buses.

The slower AC recharging points are most common in residential buildings and public overnight charging stations located in residential areas. The faster DC recharging points are usually found on highways and, to a lesser extent, in depots so that N1s can be charged quickly between journeys. For both workplaces and destinations, the faster AC recharging points predominate. A small proportion of DC recharging points are used to facilitate employees or visitors with shorter dwelling times. The main critical factor is that time is an issue. A general rule is that if there is sufficient time available for charging, it is cost-optimal to use the charging option with the lowest capacity. But in cases where 'time is money' or higher volumes have to be charged, more powerful charging solutions could prove necessary.

2.1.3.2 Charging modes

The term 'charging mode' refers to the charging technique employed by a charging system, which varies depending on the power capacity it can provide to the vehicle, how communication between the power supply and the vehicle is established, and the resulting safety level. The International Electrotechnical Commission (IEC) 61851 standard for EV conductive charging systems differentiates between four modes - mode 1, 2, 3, 4.

Mode 1

Mode 1 is the simplest as there is no intermediary between the EV and the recharging point. In other words, the EV is plugged directly into a standard socket outlet. There is no communication system between the vehicle and the recharging point, thus there is no safety system. The IEC 61851 limits the current to a maximum of 16 A and a voltage of 250 V with a single-phase system, as the slowest charging mode. It is therefore intended for charging light vehicles, such as e-bikes, scooters or quadricycles (e.g. Citroen Ami, Renault Twizy). For safety reasons, this mode is not allowed in public areas in Italy and is restricted in Denmark, Germany, France and Norway, Switzerland. Outside the EU, mode 1 is forbidden in the United States (US), Israel, and England[71].

Mode 2

As in mode 1, this charging method involves direct connection of the EV to a standard power socket, which also implies AC charging. However, to deal with the security problems associated with mode 1, the connection cable is equipped with an in-cable control pilot function and a device for personal protection (IC-CPD). Consequently, this mode can incorporate functions for detecting and monitoring protective earthing, overcurrent and overtemperature

[71] Netherlands Enterprise Agency, Electric vehicle charging: definitions and explanation, 2019.

protection[72]. Connected to an AC supply network, this mode does not exceed a current of 32 A and can reach up to 250 V in AC single-phase. With a current of 32 A, it can reach 7.4 kW with a single-phase electric power supply[73]. The most advanced versions include a charging cable with a connector for different Electrotechnical Equipment Certification (EEC) industrial sockets, allowing shorter charging times with three-phase current, i.e. up to 22 kW[74]. Mode 2 can be used with domestic and (more secure) industrial sockets than mode 1. The vehicle-side connector is Type-2.

Mode 3

Mode 3 also incorporates specific equipment for vehicle charging, with integrated control and protection functions. Unlike mode 2, however, this equipment is typically wall-mounted or on a pole, and is continuously connected to an AC power network[75]. In mode 3, the connection cable is not bundled with the wall box, which causes significant discomfort, as the user must use their own mode 3 charging cable from Type-2 to Type-2[76,77]. Although uncommon, in some cases this cable may be attached to the recharging point[78]. The recharging point contains all necessary and safety-relevant components, such as Pulse Width Modulation (PWM), communication module, Residual Current Circuit Breaker (RCCB) or surge protection[79]. Charging stations that operate in mode 3 typically support charging up to 32 A and 250 V in single-phase, and up to 32 A and 480 V in three-phase[80]. According to the Netherlands Enterprise Agency, in practice, most public charging stations deliver 11 kW (a split 22 kW charger), 22kW and in some cases even 43 kW[81]. Most on-board chargers in private M1s and N1s still have an input maximum of 11 kW, with premium vehicles going up to 16 kW or 22 kW. The input value of the vehicle is therefore the limiting factor in the charging speed. Similar to mode 2, the vehicle-side connector is Type-2.

Most charging stations in mode 3 do not come with an integrated charging cable, thus the owner must use their own cable that fits their vehicle.

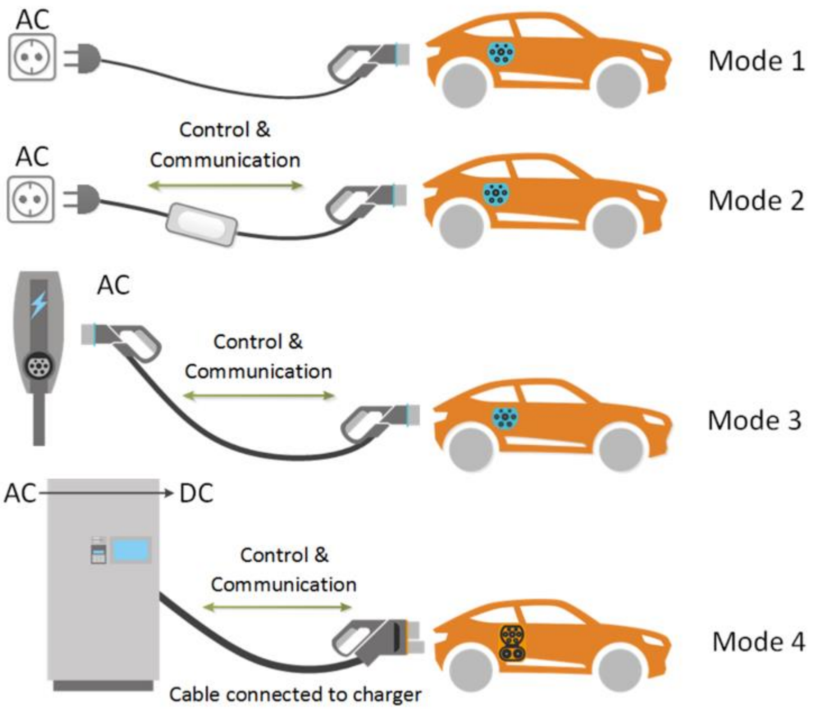
Mode 4

Mode 4 uses a vehicle charging station that incorporates a system to transform AC from the grid into DC supplied directly to the vehicle's battery. As a result, this mode is capable of rapidly charging a vehicle, allowing currents of up to 400 A and voltage of up to 800 V[82]. Dealing with such high power requires this charging mode to have even more sophisticated security and communication features than those of mode 3.

Another difference between mode 3 and 4 is that in mode 4, the cable is always attached to the charging station, for security reasons and due to the price and weight of the cable. The vehicle-side connector is CCS-Combo-2.

[72] https://www.allaboutcircuits.com/technical-articles/four-ev-charging-modes-iec61851-standard/
[73] https://www.rfwireless-world.com/Terminology/EV-charging-modes.html
[74] https://www.mobilityhouse.com/int_en/knowledge-center/charging-cable-and-plug-types
[75] https://www.allaboutcircuits.com/technical-articles/four-ev-charging-modes-iec61851-standard/
[76] https://www.mobilityhouse.com/int_en/knowledge-center/charging-cable-and-plug-types
[77] A charging cable from Type-2 to Type-1 is very rare (e.g. Nissan Leaf).
[78] https://www.emobile-bals.com/en/news-and-knowledge/lexicon/Ladebetriebsarten_EN
[79] https://www.emobile-bals.com/en/news-and-knowledge/lexicon/Ladebetriebsarten_EN
[80] https://www.dazetechnology.com/charging-modes-for-ev/
[81] Netherlands Enterprise Agency, Electric vehicle charging: definitions and explanation, 2019.
[82] https://greencars.com/post/new-800-volt-fast-charging-systems

Figure 3: Charging modes



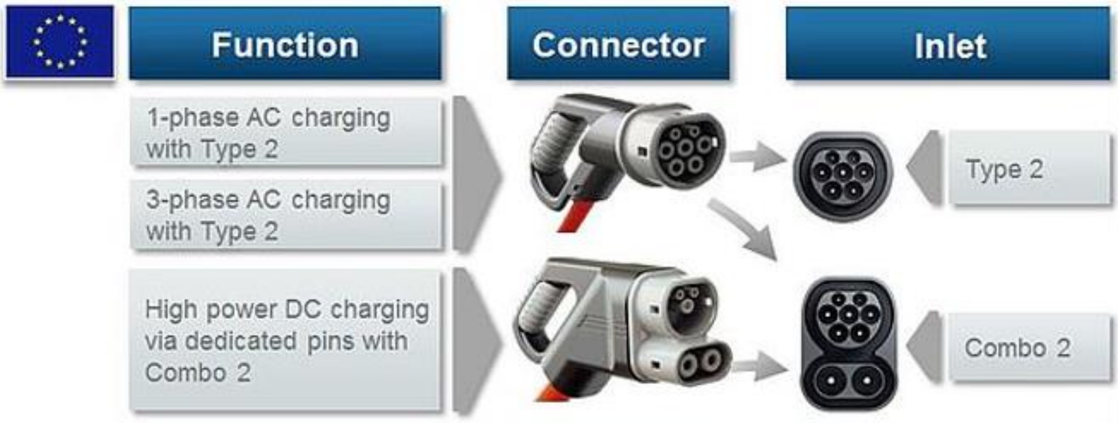
Source: Deltrix Charging Solutions, Charging modes. n.d.

2.1.3.3 Connector types

Connectors are the fixed end of a cable that plugs into the electrical socket of an EV. As the charging connector and the inlet of the vehicle differ depending on the region and EV model, it is not possible for every EV to charge at every recharging point. The type of connector generally depends on two factors – whether it is AC or DC charging, and the vehicle manufacturer itself, which will generally adopt the type of connector that is most widely used in the country where it is produced. Depending on the type of connector, it will allow different charging capacities and consequently different charging speeds[83]. To ensure interoperability in the EU, the Alternative Fuels Infrastructure Directive (AFID)[84] and the AFIR proposal[85] require that all recharging points have at least a power socket or connector for vehicles of Type-2 (Mennekes) for AC normal and high-power recharging points. In the case of high-power DC recharging points, the AFID establishes CCS-Combo-2 as the standard[86]. Figure 4 summarises these requirements.

[83] https://www.electrical-installation.org/enwiki/Electric_Vehicle_and_EV_charging_fundamentals
[84] Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure, OJ L 307, 28.10.2014.
[85] Proposal for a regulation of the European Parliament and of the Council on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU of the European Parliament and of the Council, COM(2021) 559, 2021/0223(COD).
[86] https://alternative-fuels-observatory.ec.europa.eu/general-information/charging-systems

Figure 4: Overview of EU EV connector standards



Source: European Alternative Fuels Observatory, Recharging systems. n.d.

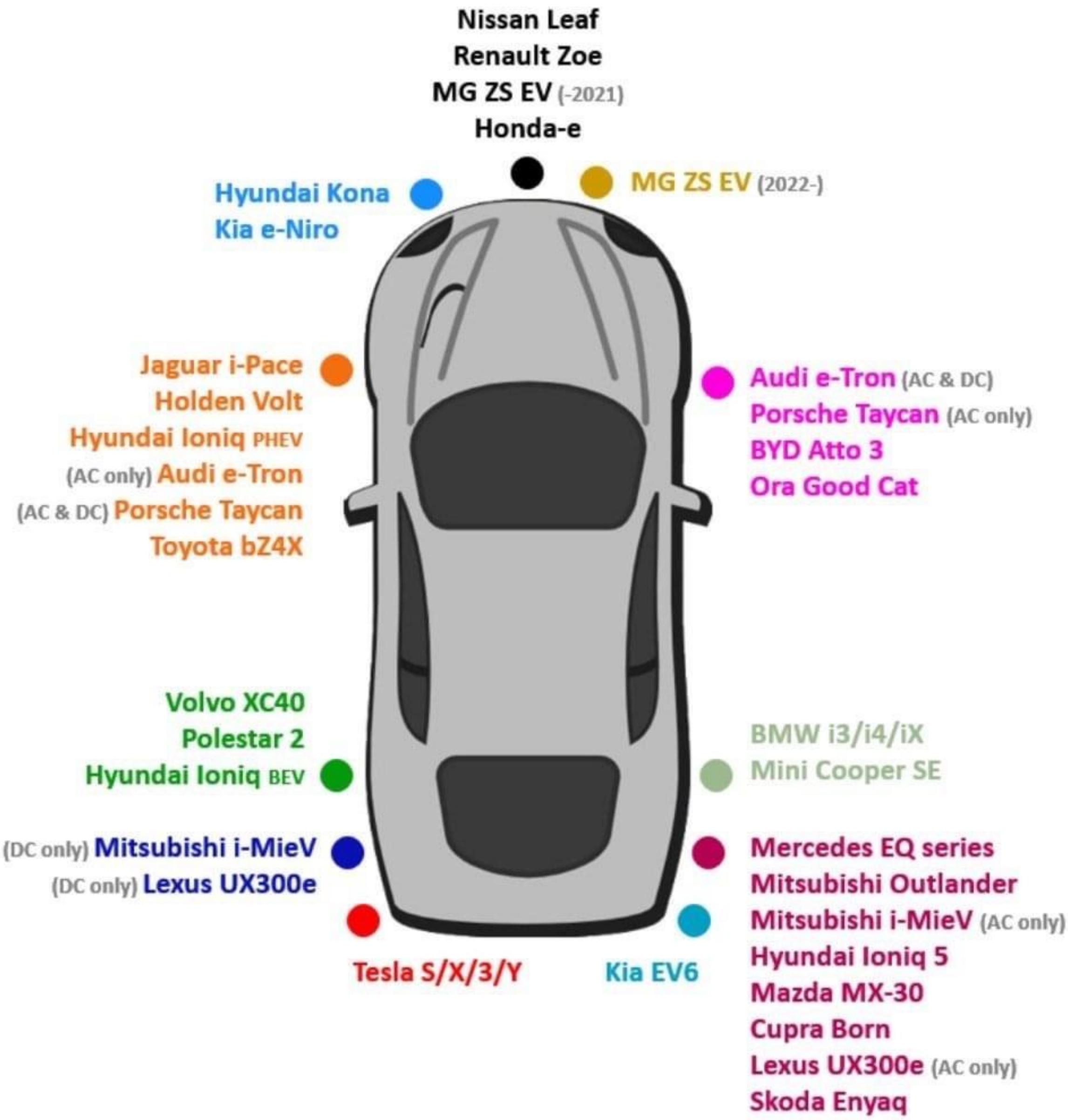
Before the adoption of the AFID, several recharging points with AC connectors other than Type-2 were installed in the EU. The prescription of the Type-2 standard in the AFID ended this practice. CCS was never used for AC. Similarly, while it has often been market practice to equip 50 kW recharging points with an additional CHAdeMO connector, more and more providers of high-power recharging points are choosing to equip their stations with CCS-Combo-2 connectors only, as even the single Japanese vehicle manufacturer has moved to CCS in its most recent vehicles[87,88].

2.1.3.4 AC and DC plug position in vehicles

The lack of a standard position of AC and DC plugs in EVs has generated a dilemma. Although for petrol/diesel, the back left or back right are the standard locations, there is no such standard for EVs. Extreme cases have a double plug, with AC and DC taking a side each (e.g. Porsche, Audi). Figure 5 shows the position of the AC and DC plug in various EVs.

[87] https://alternative-fuels-observatory.ec.europa.eu/general-information/charging-systems
[88] https://thedriven.io/2020/07/20/nissan-ariya-spells-end-of-the-road-for-electric-vehicle-charging-plug-war/

Figure 5: AC and DC plug position in EVs



Source: AEVA, [Where is the charge port on that car?](), 2022.

2.1.3.5 Recharging points in multi-family residential buildings

When designing an EV recharging system in a residential building, the first thing to decide is the configuration of the recharging point(s) to be installed. Broadly speaking, this can be a collective solution whereby all residents of the building have access to charge their EV, or an individual solution where each resident is responsible for their recharging infrastructure. Table 6 summarises the characteristics and advantages/disadvantages of each solution.

Individual solution

This solution is intended for residents with a private parking space within the homeowner association (HOA). The reason is that, once the recharging point is installed, the costs of extending the grid connection to other users is very high, as the grid connection must be adapted. While this may seem like a simple solution at first, its installation within the whole complex may cost more in the long term and become more complex to manage.

Collective solutions

The collective solution implies that several decisions on generic aspects of the installation are taken jointly and will be common to all residents. These include the expansion of the connection, the sub-distribution box and/or the smart recharging module. A fixed provider is usually the preferred choice, as it offers a major security advantage in making it easier for the building owner to manage the entire system's security. These solutions allow the installation of systems for smart control of recharging stations, improving charging efficiency. Collective solutions have two options: a basic provision, and a complete provision. In the basic provision, the HOA provides the infrastructure to enable the connection of a recharging point but does not include the recharging point itself, while the second provides both the basic facility and the recharging infrastructure provider.

Table 6: Characteristics of the three solutions for recharging EVs in buildings

	Individual	Collective – basic provision	Collective - complete
Description	HOA sets the framework, while residents arrange the recharging points and cabling	HOA provides the basic facilities (connection possibility) and residents arrange the recharging points	HOA provides a basic facility (connection possibility) and recharging infrastructure provider
Suitable for	• Small car parks • Sufficient electrical power available (including future recharging needs)	• Car parks with individual parking spaces • Large amount of electrical power available (including future recharging needs)	• Car parks with designated parking spaces • Parking garages/units with shared parking spaces • Limited electrical power available
Advantages	• Freedom to choose type of charge point • Less preparation work for HOA	• Freedom to choose type of charge point • All e-drivers can charge • Equal distribution of costs to e-drivers	• All e-drivers can charge • Equal distribution of costs • Reduced costs by optimising consumption • Future proof • Control over safety requirements
Disadvantages	• (Very) unequal cost distribution to residents in case of expansion • Limited optimisation of consumption	• Limited optimisation of consumption • Limited possibilities for expansion • Risk of complicated installation	• Lack of individual freedom to choose a charge-point provider • High preparation workload for HOA

	Individual	Collective – basic provision	Collective - complete
	• Limited possibilities for expansion, possibly insufficient capacity for all residents • Less security control • High workload for residents and HOA	• Partial control over installation quality • High workload for residents and HOA	

Source: Nationale Agenda Laadinfrastructuur, Laadoplossingen voor elektrische auto's binnen de VvE, 2022.

2.1.3.6 Pre-cabling and ducting infrastructure

The EPBD proposal contains requirements for the installation of pre-cabling for parking spaces in new or majorly renovated buildings. By laying pre-cabling during construction or renovation, considerable costs are saved, making it more attractive for the owner or user to install a recharging point.

The provision of cabling after the construction has been completed can be challenging and expensive. Additional retrofitting costs can be up to nine times higher compared to pre-cabling installed during the construction phase of the building[89]. Pre-cabling is therefore a relatively inexpensive solution that ensures the building is ready for the future.

The 2018 EPBD contains no requirements for ducting infrastructure, whereas the EPBD proposal changes the wording of requirements on pre-cabling, expanding the Directive and suggesting that electrical installation, as well as ducting infrastructure, will be part of the requirements of the new EPBD. An explicit definition of pre-cabling is not provided in the EPBD, which chiefly refers to the ducting infrastructure, including the complete installation of all necessary electrical cabling. Ducting infrastructure refers to the infrastructure that enables a dedicated, safe and unobstructed route from the electrical supply point to the location for the (future) recharging point. Various electrical containment systems achieve this, such as electric cable ducting including drawstrings, electric cable trunking or conduits, or electric cable trays and cable ladders.

Constructing ducting infrastructure must take into account the likely future location of the recharging point (floor-mounted, wall-mounted, on a pole, serving one or multiple parking spaces), the technical requirements for the recharging point related to the rated output (which sets requirements on the size, specification and bend radius of the cabling ducts), and the applicable safety requirements. The most challenging aspect is basing these plans on future demand. One development is already evident – the growth in battery capacity and thus a need for recharging solutions with higher capacities. Such requirements can be set at Member State level. In addition, each Member State will have requirements for the ducting infrastructure itself in relation to backfilling, suitable access points, presence of draw rope, prevention of water ingress and vermin attack, positioning and colour coding standards and compliance with other building requirements.

[89] Platform for Electromobility, EPBD: Reinforce the measures to ensure pre-cabling, 2022.

For pre-cabling, the wiring needs firstly depend on the number of recharging points that will need to be connected – several recharging points means several cables. The diameter of a single cable from the recharging point to the electrical supply point depends on various factors, including the distance, the voltage and the amperage used. For low power, a voltage of 230 V is assumed. In the case of low power, the length of the cable has the greatest influence on the required diameter – the longer the cable, the larger the diameter must be. The amount of amperage has a secondary influence. At higher power, this changes (partly because the voltage also changes) and the cable length becomes less important. At higher power, cable diameter must increase only when cables are longer than 75 metres. The combination of high voltage and low amperage results in thinner cables. This has to do with the heat generated by losses in the cable (more amperes means more losses and therefore more heat). It is therefore desirable at high power not to work with the standard 230 V and single-phase, but to increase this to 400 V and three-phase so as to minimise losses and limit the cable thickness.

The combined load capacity to be delivered from the electrical supply point to all chargers must also be considered. If a certain threshold (about 175 kVA) is exceeded, an extra connection to the (high voltage) power grid is needed. It may be necessary to install an additional transformer for the stability of the power supply. The power connection also has to be upgraded with cables that are about double the diameter and cost of the ‘ordinary’ (low voltage) grid cables. The distance between the location and the nearest high voltage power grid can entail serious costs, as this network is much less widespread than the low voltage (common public) network.

The wiring needs depend on the number of recharging points to be connected in the future, and whether it concerns AC or DC.

Another issue is the availability of sufficient power in the public network. While this is a serious issue that could jeopardise the pace of EV adoption, it is outside the scope of this study. The EPBD does not set specific requirements for the electrical cabling itself or for mandatory upgrades to the electrical infrastructure, such as the electrical pre-equipment in collective installations.

2.1.4 Smart charging

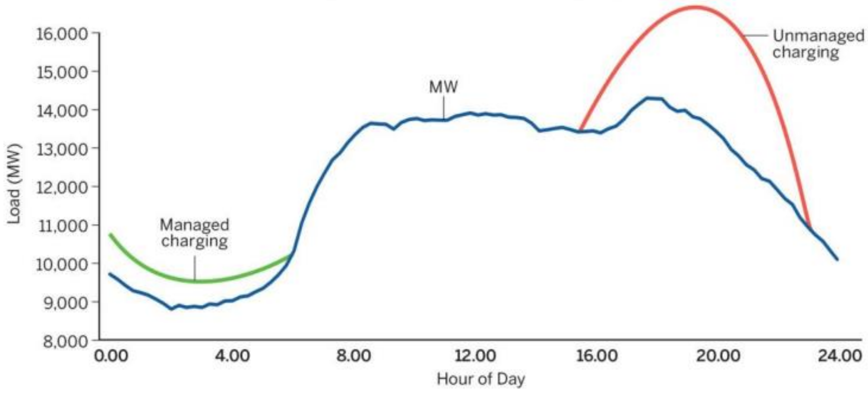
In facilitating the uptake of EVs and the resulting increased electricity demand in buildings, the concept of smart charging[90] becomes particularly important. According to the EBPD proposal, the Member States shall ensure that all recharging points installed are capable of smart charging and, where appropriate, bi-directional charging[91].

Smart charging will be crucial to cope with the rapid growth of EVs, which observed in recent years and the expected future a continued and fast growth. If left uncontrolled, EV expansion could present a challenge to the electric grid[92,93]. This is especially true at peak evening hours when people typically charge their vehicles after returning from work. Smart charging functionality makes it possible to manage vehicle charging times by prioritising those with lower demand on the electrical system and thereby reducing the risk of congestion without compromising the vehicle's readiness-for-use when needed (Figure 6). The greater the availability of smart charging systems, the lower the need to expand the electricity grid to

[90] Smart charging is a charging operation in which the intensity of electricity delivered to the battery is adjusted in real-time, based on information received through electronic communication (European Commission, proposal for the Renewable Energy Directive (COM(2021) 557)).
[91] Directive of the European Parliament and of the Council on the energy performance of buildings (recast), COM(2021) 802, Article 12, paragraph 6.
[92] Burger, J., Hildermeier, J., Jahn, A. and Rosenow, J., *The time is now: smart charging of electric vehicles*, Regulatory Assistance Project (RAP), 2022.
[93] Transport & Environment, *How implementing the Clean Energy Package can foster electromobility*, 2020.

support this growing electricity demand. A 2019 study showed that smart charging could reduce the investment needed in distribution networks by more than 50% by 2030[94].

Figure 6: Difference between managed and unmanaged load throughout the day



Source: Burger, J., Hildermeier, J., Jahn, A. and Rosenow, J., [The time is now: smart charging of electric vehicles](), Regulatory Assistance Project (RAP), 2022.

Smart charging can also facilitate the uptake of intermittent renewable electricity. Thanks to smart recharging functionalities, charging can be shifted from expensive peak periods to off-peak periods of cheaper energy or periods where abundant electricity is provided by renewable energy sources.. Trough smart charging EV users with solar panels in their properties could take also advantage of the energy generated to charge their vehicles, which not only benefits the environment but also saves them energy costs[95].

Dynamic electricity price contracts are key, promoting economic incentives to consumers in exchange for adjusting their charging habits. Given that electricity prices fluctuate greatly throughout the day, smart charging offers the possibility of benefiting from this price dynamism by automatically shifting electricity consumption to lower price periods. In this way, these prices s can simultaneously benefit both the user and the electricity system[96].

Given the potential of smart charging, the EU introduced a series of provisions within the Clean Energy Package (adopted in2019) facilitating smart charging. [97]. These include, most notably, the Electricity Directive (EU) 2019/944[98] and the Electricity Regulation (EU) 2019/943[99]. Both legislative acts aim to empower consumers by giving them more autonomy to benefit from the dynamism of market prices, thereby driving the introduction of dynamic price contracts and other flexibility services. The Electricity Directive introduced a requirement to put in place smart metering systems and obliged all electricity suppliers of a minimum size to offer dynamic electricity price contracts to optimise electricity consumption. Member States can only delay the deployment of smart metering systems if the costs outweigh the benefits. Even then, consumers – who bear the costs – are entitled to apply for a smart meter, which must be installed within four months (Article 21). In case of a positive assessment in a Member State, 80% of customers must have access to a smart metering system within seven years or by 2024 in those States where the cost analysis began before 4 July 2019. The Electricity Directive also contains provisions for aggregators facilitating the development of other flexibility

[94] Maier, U., Peter, F., Jahn, A. and Hildermeier, J., *Distribution grid planning for a successful energy transition – Focus on electromobility*, Regulatory Assistance Project (RAP), 2019.
[95] Burger, J., Hildermeier, J., Jahn, A. and Rosenow, J., *The time is now: smart charging of electric vehicles*, Regulatory Assistance Project (RAP), 2022.
[96] Ibid.
[97] Transport & Environment, *How implementing the Clean Energy Package can foster electromobility*, 2020.
[98] 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 (recast), OJ L 158/125, 14.06.2019.
[99] Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity (recast), OJ L 158/54, 14.06.2019.

services, such as demand response. The Electricity Regulation (EU) 2019/943 provides that regulatory authorities for those members that have introduced a smart metering system shall consider time-differentiated tariffs 'to reflect the use of the network, in a transparent, cost-efficient and foreseeable way for the final customer' (Article 18). The number of dynamic price contracts and other flexibility services offered by electricity market participants remains unevenly distributed across Europe. In the UK, more than 30 different electricity suppliers offer such contracts, which are not available in other countries, such as Poland and Hungary[100].

The proposal for a revision of the Renewable En (REDIII)[101] aims to increase the penetration of renewable energy and promote sector integration. Article 20a of the REDIII proposal sets out that consumers should receive information on the share of supplied renewable electricity, and that non-publicly accessible normal power recharging points can support smart charging functionalities. EVs parked in residential or office buildings for longer periods of time are able to offer flexibility and balancing services to the electricity system and thus contribute to the energy system integration. EVs can also contribute to the uptake of self-consumption (e.g. renewable electricity produced from solar panels) when parked at homes or offices.

Requirements for smart charging are also part of the AFIR Proposal[102]. The proposal contains an obligation for publicly accessible recharging points of less than 22 kW power output to support smart charging. Publicly accessible recharging points located in buildings will fall under this requirement as well.

2.1.4.1 Bi-directional charging

In addition to managing charging time, bi-directional charging technologies use EVs as decentralised storage devices that can return energy to a building or the grid when it is most needed. . Bi-directional charging between the vehicle and the building is commonly known as 'vehicle-to-home' (V2H). The purposes of this technology include storing excess solar energy obtained during the day for use by the building overnight or providing backup power to the building in case of a power outage.

While V2H technologies provide benefits for the energy balance of buildings, 'vehicle-to-grid' (V2G) technologies provides services to the grid. The idea behind V2G is to store energy from renewable sources when it is available and return it to the grid for use when production is low. V2G can contribute to grid stability by releasing the stored energy during peak periods, while also reducing investment in infrastructure caused by the expected increase in demand[103].

V2G is at an early stage of development and few vehicles are yet compatible. Two examples are the Nissan Leaf and the Mitsubishi Outlander PHEV. Both vehicles use CHAdeMO for bidirectional charging, which is DC-based and requires a relatively expensive charging station. The electronics for bi-directional charging are not in the car itself, but in the charger. V2G must still address some challenges. For example, by increasing the frequency of charging and discharging, V2G may shorten the battery life of the EV[104]. Also, the energy efficiency in bi-directional charging equipment or within the EV itself is low, both in discharging mode as well

[100] Burger, J., Hildermeier, J., Jahn, A. and Rosenow, J., *The time is now: smart charging of electric vehicles*, Regulatory Assistance Project (RAP), 2022.
[101] Proposal for a Directive of the European parliament and of the Council amending Directive (EU) 2018/2001 of the European Parliament and of the Council, Regulation (EU) 2018/1999 of the European Parliament and of the Council and Directive 98/70/EC of the European Parliament and of the Council as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652.
[102] Proposal for a Regulation of the European Parliament and of the Council on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU of the European Parliament and of the Council. COM/2021/599.
[103] Kasten, P., Bracker, J., Haller, M. and Purwanto, J., *Electric mobility in Europe – Future impact on the emissions and the energy systems*, Final report, 2016.
[104] Britto, A.B. and Krannich, K., *Why do we need vehicle to grid technology?*, n.d.

as at partial loads[105]. As home charging is typically done on AC recharging points, it increases costs, largely because it requires specialised hardware for conversion to AC[106]. There is uncertainty about the ways in which revenue is generated by V2G technologies and the size and distribution of that potential revenue. In addition to these technical and economic challenges, functioning electricity flexibility markets and non-discriminatory (near) real-time access to battery data (to ensure the development of competitive service-side markets) are also required if bi-directional charging is to be further developed for the market.

Given the advances in vehicle charging technology, it is expected that from 2022 more vehicles will be able to support bi-directional loading employing the ISO 15118-20 standard and the European standard plug[107]. For instance, Volkswagen plans to enable bi-directional charging in all models with 77 kWh batteries[108].

The Electricity Market Design paves the way by requiring Member States to adopt measures to allow and facilitate self-generation and energy storage measures, for both self-consumption and sale. The AFIR and the REDII proposals provide further measures for promoting bi-directional charging due to its role in maximising the use of renewable energy and ensuring flexibility of the energy system.

2.2 Analysis of available recharging points in residential and non-residential building and projections for 2025, 2030, 2050

This section analyses the number and type of available recharging points[109] in residential and non-residential buildings. This is followed by projections for 2025 to 2050, with specific results reported for 2025, 2030 and 2050. Unfortunately, there is a dearth of detailed statistics on the number and nature of recharging points in the European building stock, preventing a refined analysis of the impact of the EPBD proposal on building recharging infrastructure. Assumptions are used to synthesise a plausible dataset on available recharging points, based on triangulation of data from different datasets.

2.2.1 Charging points in 2020

Both privately accessible recharging points and publicly accessible recharging points located near residential and non-residential buildings are relevant for the EPBD. A recharging point is considered private when access is restricted to a limited, pre-determined set of people, such as parking lots in residential buildings that are accessible only to residents or authorised persons. If a recharging point is located on private property but accessible to the general public, it is considered publicly accessible, including in cases where access is restricted to a certain general group of users (e.g. customers).

The total number of recharging points in buildings falling under the scope of the EPBD is unknown as there are no reporting obligations by Member States. The national implementation plans submitted by the Member States under the AFID[110] mostly contain information on the

[105] Ghotge et al., 'Challenges for the design of a Vehicle-to-Grid Living Lab', *Proceedings of 2019 IEEE PES Innovative Smart Grid Technologies Europe (ISGT-Europe 2019),* Institute of Electrical and Electronics Engineers (IEEE), 2019.
[106] Ibid.
[107] Burger, J., Hildermeier, J., Jahn, A. and Rosenow, J., *The time is now: smart charging of electric vehicles*, Regulatory Assistance Project (RAP), 2022.
[108] Schmidt, B., 'Volkswagen electric cars to power homes by end 2022', 2022.
[109] In this study, the same definition for a 'charging point' is used as in the Commission's proposal for the AFIR, i.e. fixed or mobile interface that allows for the transfer of electricity to an EV, which, whilst it may have one or several connectors to accommodate different connector types, is capable of charging only one EV at a time, and excludes devices with a power output less than or equal to 3.7 kW or whose primary purpose is not charging EV.
[110] Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative

publicly accessible recharging points. Accordingly, the numbers of public and private recharging points are estimated separately.

2.2.1.1 Private recharging points

To estimate the current number of residential recharging points, the study assumed a fixed ratio per EV. Not every home has a private driveway, thus not every EV car user has access to a recharging point at home. Transport & Environment (2020) estimated a current average of 0.8 private chargers at home per EV[111].

Based on the total number of EVs (BEV+PHEV), the number of recharging points at private homes can then be derived. The European Alternative Fuels Observatory (EAFO) reports that in 2021, there were over 5.3 million EVs in Europe[112], an increase of 70% compared to 2020, when the number of EVs in Europe was 3.1 million. If 80% of EV drivers have a recharging point at home, this means that in 2021, there was an estimated total of around 4.2 million recharging points at home in Europe.

This figure can also be used to estimate the number of recharging points at the workplace. According to Transport & Environment, 60% of all energy is charged at home and 15% at work, i.e. there are four times more recharging points at home than at work. This yields an estimate of 1.0 million recharging points at the workplace, which are mostly private, but can also be publicly accessible. This brings the total number of private recharging points to 5.2 million, or around one private recharging point per EV[113].

The estimated number of private recharging points for N1s is derived from the total number of N1s in 2020. According to modelling data from DG ENER, there were some 227,000 N1s[114] in Europe in 2020. As with M1s, it is assumed that there will be about one private recharging point per N1[115]. A report by Top Sector Logistics (2021) indicated that in the Netherlands, about 51% of private recharging takes place at the workplace and 49% at home[116], as it is far more common for the user to leave the EV at the workplace overnight to fully charge it. This means that there are some 114,000 recharging points for N1s in workplaces and 112,000 in homes, bringing the total number of estimated private recharging points to 5.6 million in 2020.

Table 7: Estimated number of private recharging points in homes and workplaces in 2020

EV type	Location	Number of private recharging points (thousands)
Cars	Home	4,263
Cars	Workplace	1,066
Vans	Home	112
Vans	Workplace	114

fuels infrastructure, OJ L 307, 28.10.2014.
[111] Transport & Environment, *How many charge points will Europe and its Member States need in 2020s?*, 2020.
[112] https://alternative-fuels-observatory.ec.europa.eu; figures include EU, UK, European Free Trade Association (EFTA) countries and Turkey.
[113] This ratio corresponds to the estimate in Global EV Outlook, *Entering a decade of electric drive?, 2020.*
[114] Other sources may publish different figures due to different methods used to calculate the figures.
[115] As in Top Sector Logistics (2021), it is assumed that every van needs a private recharging point to charge overnight, either at home or at work.
[116] Top Sector Logistics, *Charging infrastructure for electric vehicles in city logistics*, 2021.

EV type	Location	Number of private recharging points (thousands)
	Total	5,555

2.2.1.2 Publicly accessible recharging points

Member States collect information on publicly accessible recharging points for the national implementation plans submitted under the AFID. According to the EAFO, there were around 330,000 public recharging points in Europe in 2021[117], 22% higher than in 2020. Around 18% of the public recharging points are classified as fast-charging (charging capacity > 22 kW), while 82% are classified as slow-charging. The recharging points are highly concentrated in a number of countries, with the Netherlands, Germany, England, France and Italy together accounting for more than two-thirds of all recharging points in Europe.

Public recharging points can be found both on-street and off-street (in buildings). The EAFO provides information on the locations of the public recharging points via TENtec. However, TENtec does not provide information for all existing points, and other sources have been used to derive the share of public recharging points in various types of buildings:

- Combining crowd-sourced data of the location of recharging points on Chargemap and Zap-map[118] provides information on all off-street recharging points, such as those located at hotels, shops and retail car parks. Based on these two sources, an estimated 48% of all public chargers are located in buildings.
- Colle et al. (2022)[119] provide information on recharging points located at 'destinations', i.e. places where you charge for convenience while engaged in other activities. This source estimates the share of public destination chargers compared to on-street public chargers at 58%.
- ACEA (2022)[120] estimates the total number of public recharging points at destinations at 42%.

The estimates from the three sources are not dissimilar, suggesting a degree of accuracy. The average of the three figures was used for the impact assessment, i.e. it assumed that 49% of all public chargers are located in or adjacent to residential and non-residential buildings. This statistic does not include private recharging points next to workplaces, as these are already considered private recharging points. In practice, some of these private recharging points in workplaces will be public.

The remaining 51% of all public recharging points are located on-street, e.g. parking spaces, public car parks, along the highway, at stations and airports. These are not within scope of the EPBD but are within scope of the AFIR. With a total of 330,000 public recharging points in Europe according to EAFO, some 162,000 are located in non-residential buildings.

[117] https://www.eafo.eu/alternative-fuels/electricity/charging-infra-stats; figures include EU, UK, EFTA and Turkey.
[118] Statics primarily derived from Chargemap (https://chargemap.com/about/stats/). Its dataset contains information on around 156,000 charging pools and 508,000 charging plugs worldwide, but by far most of the data are for European countries. The location of around 32% of the recharging points are unknown and have been excluded. Approximately 30% of the recharging points can be found in car parks. Based on statistics from Zapmap (https://www.zap-map.com/free-ev-charging-points-where-are-they/), 49% of these are in public car parks, 32% to retail car parks and 19% to workplace car parks.
[119] Colle, S. and Ruby, K., *Power sector accelerating e-mobility. Can utilities turn EVs into a grid asset?*, 2022.
[120] ACEA, *European EV Charging Infrastructure Masterplan*, 2022.

Table 8: Estimated number of public recharging points on-street and off-street (in buildings) in 2020

EV type	Location	Number of public recharging points (x 1.000)
Cars and vans	On-street	168
Cars and vans	Off-street	162
	Total	330

2.2.2 Projections for recharging points in buildings for 2025, 2030, 2050

Estimates of future demand for recharging points at buildings are derived from the expected growth in EVs. Expected EV growth can be translated into the number of recharging points needed to sustain that growth. The need for recharging points is then split over different types of buildings. Finally, the section presents the resulting future demand for recharging points in residential and non-residential buildings.

2.2.2.1 Forecasted EV growth

The forecasted number of recharging points in buildings is derived from the forecasted number of EVs in Europe. DG ENER modelling data that was used for the ‘Fit for 55’ policy package provides estimates of the expected growth of the EV market (see Figure 7). Two scenarios are used in the forecast: the **EU reference** scenario[121] and the **EU MIX**[122] scenario. Figure 7 shows that 5.5 million EVs in Europe in 2020, which is expected to increase to 44-51 million by 2030 and 151-250 million by 2050, depending on the scenario.

The share of EV vans is projected to increase from about 4% to 6% in 2030 and 11% in 2050. One of the main differences in both scenarios – apart from the total number of forecast EVs – is the share of BEV versus PHEV. Currently, 44% of the total number of EVs are BEVs. In the reference scenario this rises to 58% in 2050, while in the MIX scenario, this share increases to 83% in 2050.

Projections of EV use in a dynamic market

The market for EVs is characterised by constant change due to rapid development, posing a challenge to any study projecting EVs, as data used to derive forecasts can quickly become outdated.

An important input into this study is the forecasted growth of EVs. Data were provided by the European Commission in the form of modelling data used for the ‘Fit for 55’ policy package.

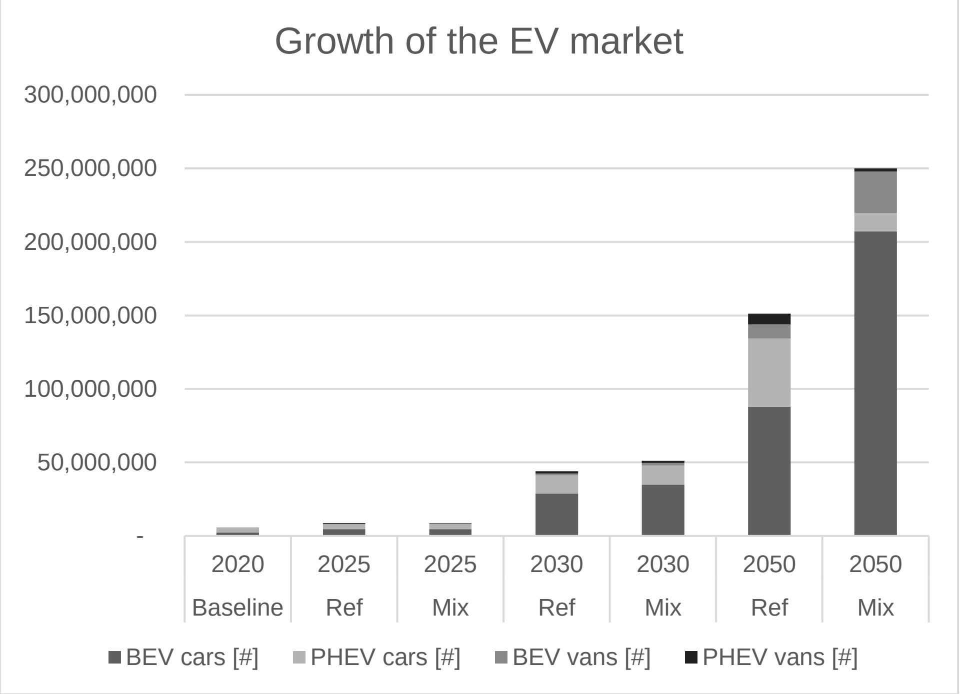
However, since that work was done, there have been further significant changes affecting the market. More specifically, it seems likely that ICEs will be replaced by EVs faster than previously projected. Several car manufacturers have recently announced plans to accelerate the production of EVs[123], partly in response to the introduction of the EURO 7

[121] https://energy.ec.europa.eu/data-and-analysis/energy-modelling/eu-reference-scenario-2020_en
[122] https://energy.ec.europa.eu/data-and-analysis/energy-modelling/policy-scenarios-delivering-european-green-deal_en
[123] For example, Volvo (https://www.carscoops.com/2021/03/volvo-to-kill-their-ice-offerings-by-2030-new-cars-to-be-online-exclusive-pure-evs/), Jaguar (https://www.edie.net/jaguar-to-switch-to-fully-electric-vehicle-portfolio-by-2025/), Mercedes:

legislation in 2025[124]. In addition, sharp rises in fuel prices due to the war in Ukraine may prompt more people to consider switching to EVs[125].

The EV growth figures used in this study are thus likely to underestimate the real demand.

Figure 7: Growth of the EV market, based on modelling data from DG ENER



2.2.2.2 Forecasted number of recharging points

Based on the projected growth in the EV market in the 'Fit for 55' package, the number of required recharging points linked to buildings can be estimated. The same set of assumptions is applied as that used to estimate the recharging infrastructure for 2020. It also projects that a greater proportion of charging events at workplaces and in public spaces rather than home charging, principally because the number of EV users living in urban areas and without access to private parking (e.g. living in apartment blocks) is expected to increase[126]. In addition, EVs are expected to make longer journeys, which will require greater access to public charging facilities and increased use of high-capacity recharging points. Due to their smaller battery size and the technical limitations of using fast recharging points, PHEVs can only be charged at normal, publicly accessible recharging points.

Accordingly, the AFIR proposal[127] assumes that in 2030, 40% of BEV charging will be at public recharging points (33% for PHEV). In this context, 'public charging' includes charging at workplaces, meaning that these figures do not provide sufficient guidance to properly

(https://insideevs.com/news/520216/mercedes-ice-to-ev-transition/), FIAT (https://www.autocar.co.uk/car-news/electric-cars/fiat-become-electric-only-brand-worldwide-2030) and Ford. (https://www.nytimes.com/2021/02/17/business/ford-says-it-will-phase-out-gasoline-powered-vehicles-in-europe.html).

[124] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12313-European-vehicle-emissions-standards-Euro-7-for-cars-vans-lorries-and-buses_en

[125] McKerracher, C., 'EV markets feel the impact of war', Bloomberg, 15 March 2022.

[126] Proposal for a Regulation of the European Parliament and of the Council on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU of the European Parliament and of the Council, COM(2021) 559.

[127] Proposal for a Regulation of the European Parliament and of the Council on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU of the European Parliament and of the Council, COM(2021) 559.

distinguish between the increase in charging at residential buildings, workplaces and other non-residential buildings.

Sources use different estimates for the distribution of charging events at different locations. For example, looking at the share of charging events at the workplace, estimates range from 6%[128] to 24%[129], 26%[130] and 38%[131]. This illustrates the considerable uncertainty about future developments.

This study used the distribution per location reported in Transport & Environment (2020), partly because its figures lie around the average of the four sources noted, and partly because it also provides estimates for 2020 and 2030, allowing annual development to be deduced. The annual changes in the ratios from this source are applied to the current figures on the share of recharging points at the various locations, which are based on the energy-based calculation methodology used in the AFIR. Table 9 presents the estimated expected development of the distribution of recharging points.

Table 9: Distribution of recharging point, by location type, 2020-2050

Location	2020	2025	2030	2050[132]
Residential (private)	76%	69%	61%	52%
Workplace (private)	19%	25%	32%	41%
Public charging	5%	6%	7%	8%

The share of recharging points per location is not equal to the share of energy charged per location. The energy demand at public recharging points is higher because more use is made of fast charging at these locations. Public recharging points along motorways are used for fast charging between destinations and often have a higher charging capacity than public recharging points in residential areas that are predominantly used for overnight charging.

2.2.2.3 Charging points for different building types

Based on the European Building Stock database[133], the distribution of recharging points per residential building type[134] was estimated. About 52% of the demand for recharging points is in single-family houses, 21% in multi-family buildings with fewer than 10 dwellings and 27% in multi-family buildings with more than 10 dwellings.

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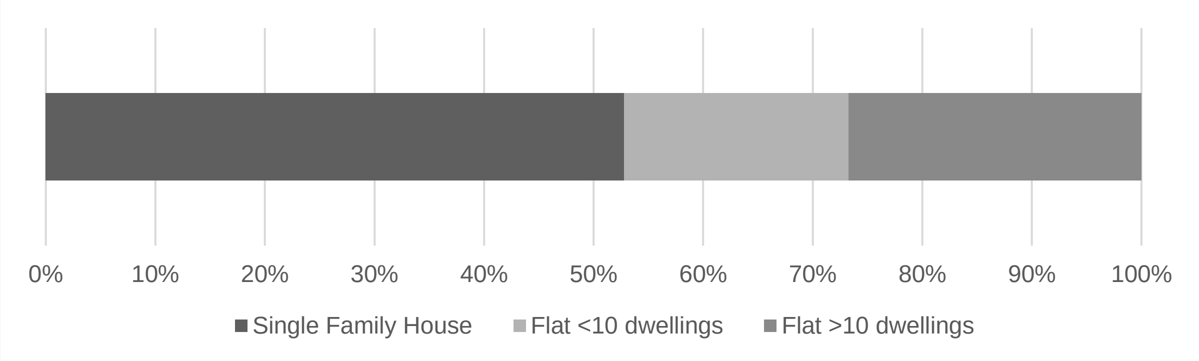
[128] Colle, S. and Ruby, K., *Power sector accelerating e-mobility. Can utilities turn EVs into a grid asset?*, 2022.
[129] International Energy Agency (IEA), Global EV outlook 2021, 2022.
[130] Transport & Environment, *How many charge points will Europe and its Member States need in 2020s?*, 2020.
[131] ACEA, European EV Charging Infrastructure Masterplan, 2022.
[132] Transport & Environment forecast only runs to 2030. To arrive at figures for 2050, the same change in distribution between 2020 and 2030 was used. The proportion of home recharging points corresponds to Transport & Environment's expectation that, given the total building stock, some 50% of EV users will charge at home.
[133] The European Building Stock Database was established under the Horizon 2020 project 'Hotmaps Toolbox' and is available at: https://gitlab.com/hotmaps/building-stock/-/blob/master/data/building_stock.xlsx
[134] Estimate calculated by dividing the total floor area per house type by the average size per house type.

Figure 8: Demand for recharging points in different types of residential buildings



Calculating the demand for recharging points in non-residential buildings requires several steps. As in the previous EPBD impact assessment, five non-residential building types are distinguished:

1. Offices;
2. Wholesale and retail trade buildings;
3. Educational buildings;
4. Tourism (including hotels and restaurants) and healthcare;
5. Others (e.g. sports facilities).

These types of buildings require a mix of private charging for employees and public charging for visitors.

The breakdown of 'charging demand at the workplace' by building type is based on data on the proportion of parking spaces per type of non-residential building intended for visitors and employees. These data are combined with the parking norms[135] and total floor area by type of destination (see Table 10).

Based on these data, the total number of parking spaces for employees and visitors per non-residential building is determined (see Table 11). The total demand for recharging points at work locations was then divided based on the proportion of parking spaces for employees per non-residential building. For example, 45% of all employee parking spaces are at offices, suggesting that 45% of the total demand for recharging points at work locations is at offices.

The same method was used to determine the demand for public recharging infrastructure at non-residential buildings. This was done on the basis of parking spaces for visitors.

Table 10: Assumptions about parking spaces for different types of non-residential buildings

Non-residential building type	Share of parking spaces for employees	Share of parking spaces for visitors	Floor space (in million sqm)	Parking norms (parking spaces per 100 sqm)
Office buildings	90%	10%	1,501	1.7

[135] Parking norms are recommendations on how much parking is needed per unit floor area as a function of the building type. See Annex X1 for an explanation of the methodology of the impact assessment.

Non-residential building type	Share of parking spaces for employees	Share of parking spaces for visitors	Floor space (in million sqm)	Parking norms (parking spaces per 100 sqm)
Wholesale and retail trade	9%	91%	1,486	3.6
Tourism and health	6%	94%	905	2.6
Educational buildings	43%	57%	1,304	2.3
Others (e.g. sport facilities)	71%	29%	1,111	1.1

Table 11: Assumptions on number and proportion of parking spaces for employees and visitors for different types of non-residential buildings

	Number of parking spaces for employees		Number of parking spaces for visitors	
	Total (in ten thousands)	Share[a]	Total (in ten thousands)	Share [a]
Offices	2,297	45%	255	3%
Wholesale and retail trade	468	9%	4,882	52%
Others (e.g. sports facilities)	149	3%	2,204	23%
Tourism healthcare (including restaurants)	1,282	25%	1,717	18%
Educational buildings	868	17%	354	4%

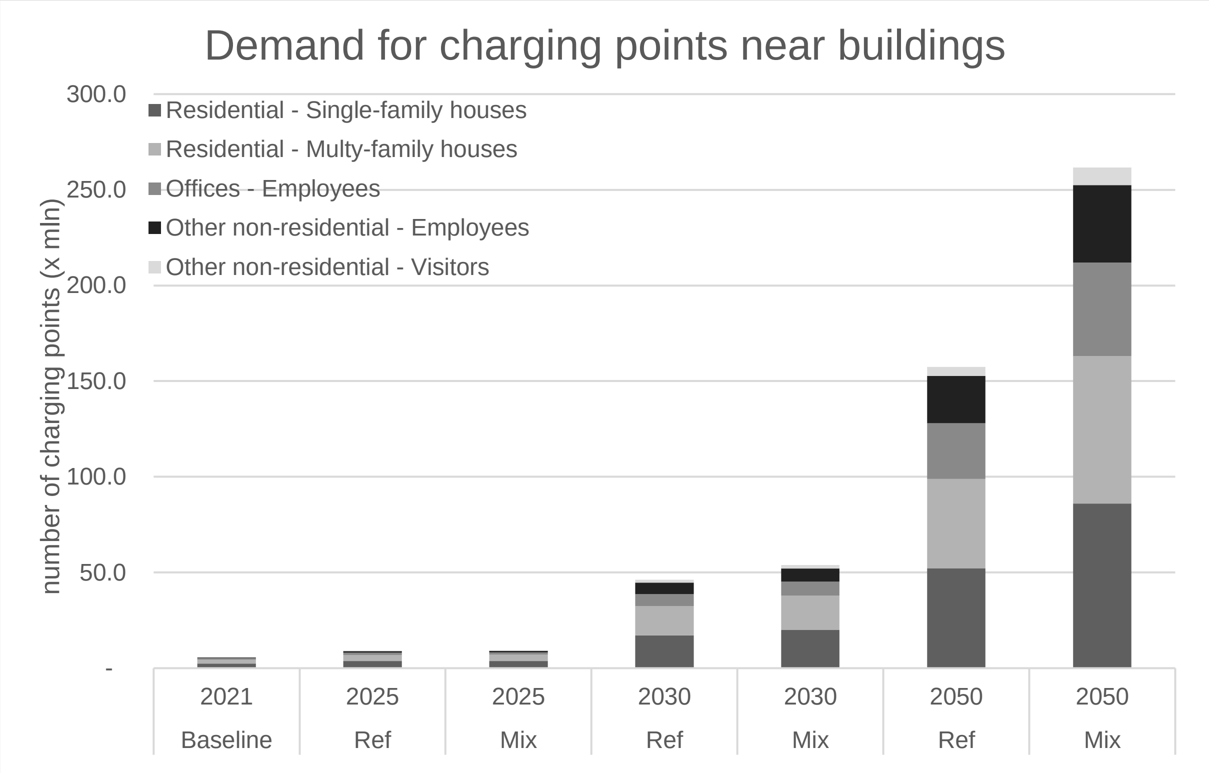
Note: a) Shares refer to the shares of the EU total non-residential sector.

For N1s, it was assumed that non-residential charging (i.e. charging at the workplace) is only done at offices, which in many cases involves depot charging. They will only use charging at customers' premises when the availability is there. If they do have to charge en route, they will generally do so at public fast-recharging points on the street.

2.2.2.4 Future demand for recharging points in buildings

Based on several assumptions on (i) expected number of EVs, (ii) forecasted number of recharging points to satisfy demand, and (iii) distribution of recharging points per location, the total demand for recharging points linked to buildings was estimated. The results are shown in Figure 9 and Table 12 for the 'Fit for 55' reference and MIX scenarios, respectively.

Figure 9: Current and projected demand for recharging points in buildings, by building type and type of recharging point



The total number of recharging points in buildings in 2021 was estimated at 5.7 million, of which 4.4 million were in residential buildings and 1.3 million in non-residential buildings. In 2030, this number is expected to increase to 46-54 million recharging points, of which some 32-38 million will be in residential buildings and 14-16 million in non-residential buildings. By 2050, that number is expected to rise to 157-261 million recharging points, of which 99-163 million will be in residential buildings and 58-98 million in non-residential buildings.

Table 12: Current and projected demand for recharging points in buildings, by building type and type of recharging point

Building type	Current (million)	Projections (million)		
	2021	2025	2030	2050
Residential – single-family houses (private, for residents)	2.3	6,9-7.1	17-20	52-86
Residential – multi-family buildings (private, for residents)	2.1	3.3-3.4	15-18	47-77
Offices (private or public)	0.9	1.0-1.1	6-7	29-49
Other non-residential buildings (private, for employees)	0.3	0.8-0.9	6-7	25-40

Building type	Current (million)	Projections (million)		
Other non-residential buildings (public, for visitors)	0.2	0.2-0.3	1-2	5-9
Total[136]	5.7	9.0-9.3	46-54	157-261

In the future, more and more EV users are expected to use charging at the workplace. In 2020, about 20% of all private charging took place at the office, with the rest at home, but in 2030, the share of charging at the office is projected to rise to 35% in both the reference and MIX scenario. In 2050, 44% of all private recharging points are expected to be located at offices. Around one-third of the recharging points in non-residential buildings (excluding offices) are projected to be public recharging points for visitors, with the remaining two-thirds being private recharging points for employees in these types of non-residential buildings. The share of publicly accessible recharging points is expected to fall to about one-quarter in 2050, due to the increasing demand for private workplace charging.

2.2.2.5 Energy consumption

The transition to e-mobility will increase the total electricity demand considerably. Once 80% of EU passenger cars become electric, the consumption of electricity will increase by 10-15%[137], depending on the Member State.

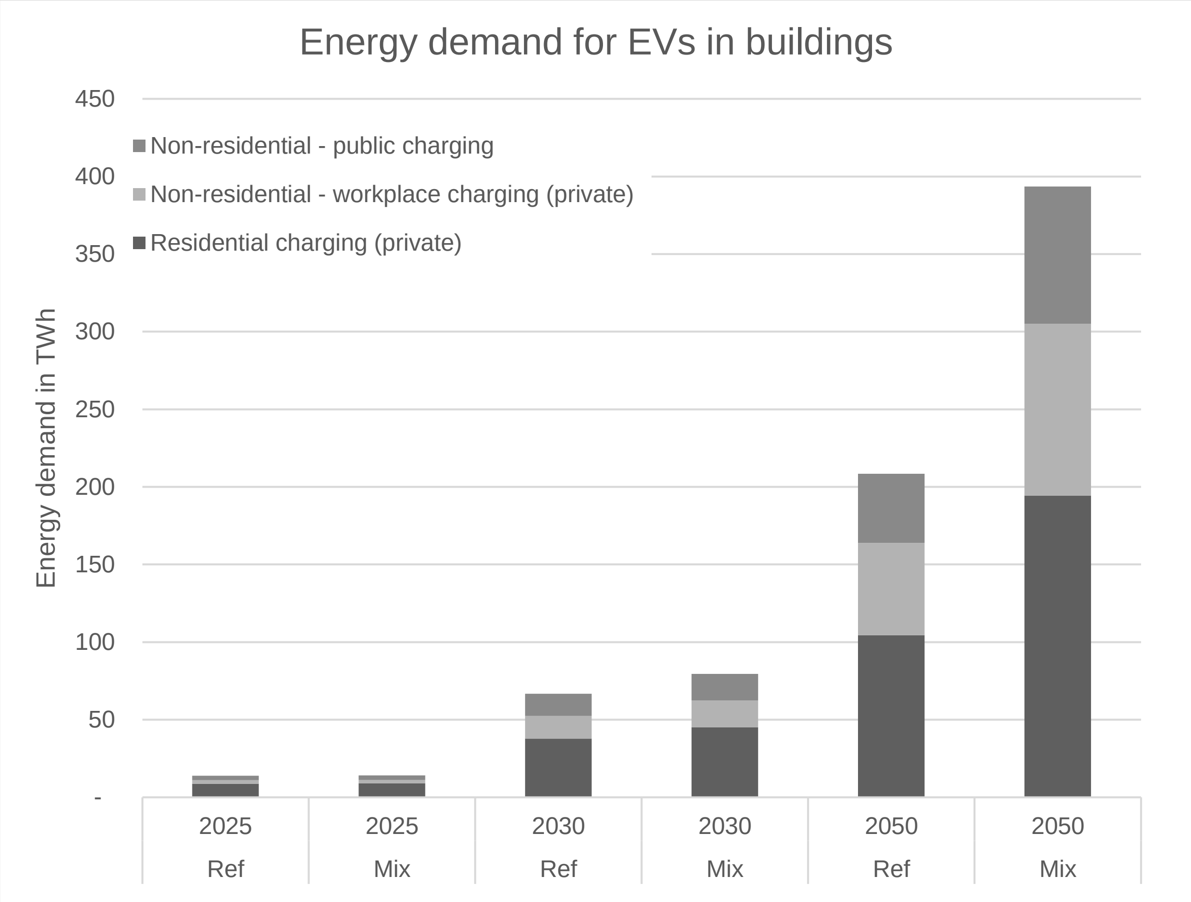
That total electricity demand can be derived from the expected growth in EV use. The same assumptions were used as those for M1s in the AFIR[138] and for N1s in Top Sector Logistics (2021)[139]. The total energy demand is derived from assumptions on annual kilometers driven, the energy efficiency of the batteries, and the share of energy charged publicly and privately. Two further assumptions are:

- According to the ACEA (2022)[140], around 44% of all energy charges at public recharging points takes place at destinations;
- For 2050, an efficiency gain of batteries of 15% compared to 2030 is assumed, based on ChargeUp Europe (2021)[141].

Figure 10 shows the expected electricity demand in residential and non-residential locations. In 2025, the total energy consumed at buildings is estimated to be 14 TWh, growing to 67-79 TWh in 2030 and 208-394 TWh in 2050.

[136] Due to rounding, some totals may not correspond with the sum of individual figures.
[137] Eurelectric, Decarbonisation pathways. Full study results, 2018.
[138] Proposal for a Regulation of the European Parliament and of the Council on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU of the European Parliament and of the Council, COM(2021) 559.
[139] Top Sector Logistics, *Charging infrastructure for electric vehicles in city logistics*, 2021.
[140] ACEA, *European EV Charging Infrastructure Masterplan, 2022.*
[141] ChargeUp Europe, *Charging up Europe through binding capacity targets for publicly accessible charging infrastructure and Member State action plans*, 2021.

Figure 10: Projected energy demand for recharging points in buildings, by building type and type of recharging point



As expected, the proportion of energy demand at workplaces increases over time. Locations with a high proportion of visitors compared to employees (i.e. locations where more public recharging points are needed) have a higher energy demand because they use faster charging compared to home and workplace charging.

2.3 Estimates and projections of recharging points in buildings: needs and opportunities for the next 5, 10 and 30 years in areas within scope of the EPBD proposal

Estimates and projections of recharging points in buildings within scope of the EPBD proposal for 2030 and 2050[142] are based on the basic data identified in section 2.2 and the obligations determined in the proposal to amend the EPBD[143]. The relevant e-mobility proposals are listed under Article 12 of the EPBD proposal and summarised in Table 13.

[142] Due to the transition period of the proposed EPBD, the first results of implementation by the Member States would be expected during 2027. 2025 has therefore been omitted from the analysis and the focus is on the years 2030 and 2050.
[143] Proposal for a Directive of the European Parliament and of the Council on the energy performance of buildings (recast), COM(2021) 802.

Table 13 Relevant obligations from the EPBD proposal

Building type	Status	Scope	Requirements
Non-residential	All buildings	> 20 parking spaces	• Installation of 1 recharging point for every 10 parking spaces by January 2027
	New and major renovations	> 5 parking spaces	• Installation of at least 1 recharging point • Installation of pre-cabling for every parking space • For office buildings: 1 point per 2 parking spaces
Residential	New and major renovations	> 3 parking spaces	Pre-cabling for every parking space

This section presents the results of the comparison of estimated supply of recharging infrastructure under the provisions within the EPBD proposal to the demand expressed via the ‘Fit for 55’ scenarios outlined in section 2.2. The method used to determine the supply of recharging infrastructure in buildings within the scope of the EPBD proposal, including sources and assumptions, is described in Annex X1.

2.3.1 Impact assessment results

The set of assumptions in the previous section allows the determination of the recharging infrastructure that would be realised under the EPBD proposal for 2030 and 2050. A distinction is drawn between the following three types of locations:

- Residential buildings;
- Offices;
- Other non-residential buildings.

For each location, a distinction is also made between the types of buildings for which different requirements apply, namely existing and new and renovated buildings[144], and between buildings with different required numbers of parking spaces. The demand for recharging infrastructure identified in the previous step is divided proportionally over the parking spaces in these types of buildings. This ensures that supply and demand are compared correctly.

The following example explains this in more detail: in 2030, 5% of all parking spaces at non-residential buildings will be located at the building category ‘new and renovated non-residential buildings with more than 20 parking spaces’. The assumption is therefore that 5% of the total demand for recharging infrastructure at non-residential buildings is also at ‘new and renovated non-residential buildings with more than 20 parking spaces’.

Comparison with the previous EPBD impact assessment

[144] As further detailed in Annex X1, the rate of renovation is consistent with the Renovation Wave Strategy and EPBD targets. Thus, the results that are reliant on renovation are dependent on the extent to which renovation targets are met.

In Annex I to the EPBD proposal[145], the European Commission estimated the infrastructure that would be realised as a result of various EPBD policy options proposed at the time.

For the sake of consistency, the same assumptions were used in this study where possible, but were enriched in several respects:

- Whereas in the previous assessment, the parking norms were determined on the basis of expert judgement, in this study, the parking norms were re-estimated on the basis of parking norms used in practice (see Annex X1 for a description of that re-estimation);
- The proportion of on-street and off-street parking spaces was taken into account, as only the off-street parking spaces fall within the scope of the EPBD.
- The average size of various building types was re-estimated using the European Building Stock Database. This database allows a better estimate to be made of the proportion of buildings with more than 3, 5 or 20 parking spaces.

This section discusses the results based on these improved assumptions. However, Annex X2 shows the results using the same assumptions as in the previous study. The main difference is that the previous assessment resulted in a lower estimate of the recharging infrastructure realised. There was also a lower market reach for non-residential buildings (i.e. fewer non-residential buildings fall within the scope of the EPBD proposal), due to lower assumptions on the average size of buildings and thus fewer buildings with more than 20 parking spaces.

2.3.1.1 Residential buildings

The provisions of the EPBD proposal for residential buildings are described below.

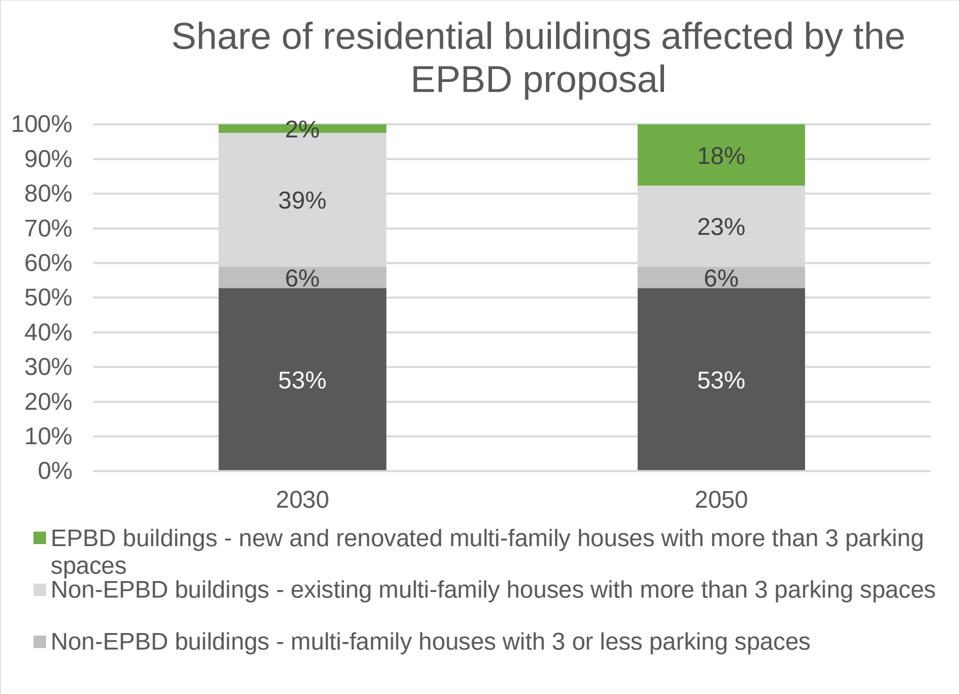
Article 12(4) of the EPBD proposal: for new buildings and buildings undergoing major renovations with more than three parking spaces: pre-cabling for all parking spaces

The scope of the EPBD proposal for residential buildings is limited to new buildings and buildings undergoing major renovation. Due to the requirement of ‘more than three parking spaces’, almost all single-family houses fall outside the scope of the EPBD proposal. Accordingly, this provision is estimated to affect 53% of the total floor area of residential buildings.

Figure 11 shows the share of the total market demand for recharging points in different types of residential buildings covered by the EPBD proposal. This illustrates the potential market impact of the EPBD proposal for residential buildings[146].

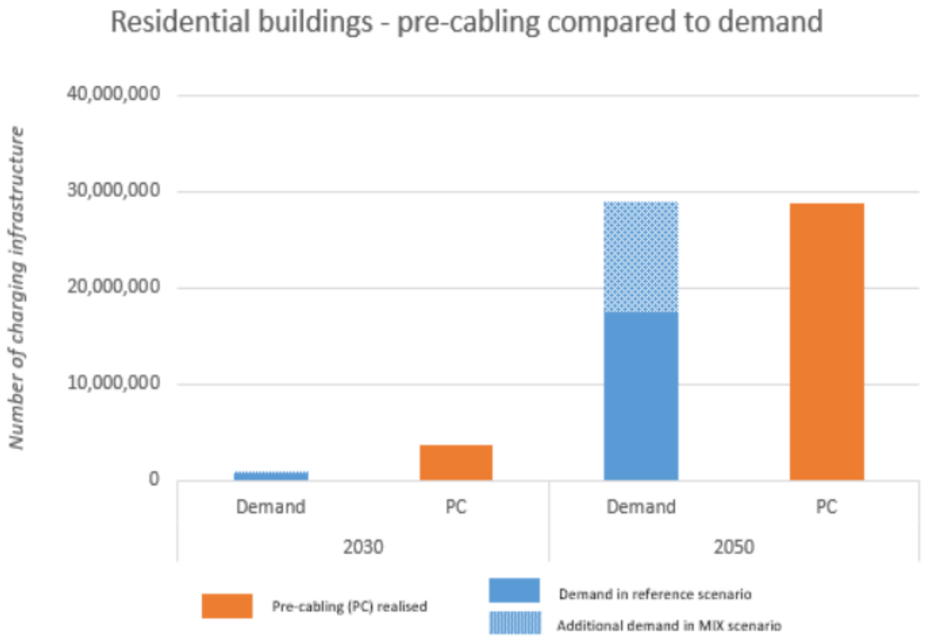
[145] Directive of the European Parliament and of the Council on the energy performance of buildings (recast), COM(2021) 802.
[146] The market share per building type was determined based on the number of dwellings per building type from the European Building Stock Database. Single-family houses represent 62% of the total floor area, but due to the higher average floor area per dwelling (98 sqm for single-family houses compared to 67 sqm for dwellings in multi-family buildings), the share of the population living in single-family houses is estimated at 53%, compared to 47% for multi-family buildings - assuming the average household size is the same for both types of buildings.

Figure 11: Share of demand for recharging points in residential buildings affected by the EPBD proposal measures at a given moment, by building type



In 2030, 2% of the demand for recharging points in residential buildings is affected by the EPBD proposal measures. Looking only at multi-family buildings, this percentage is 4%. In 2050, the percentages are estimated to be 18% for all residential buildings and 36% for multi-family buildings. The European Commission particularly supports the realisation of recharging infrastructure in multi-family buildings, reflecting that intention in the EPBD.

Figure 12: Comparison of supply and demand of recharging infrastructure in residential buildings within scope of the EPBD proposal



The next step is to compare the demand for recharging points at buildings within the scope of the EPBD proposal with the supply of recharging infrastructure stimulated by the EPBD proposal. The results are shown in Figure 12**Error! Reference source not found.**.

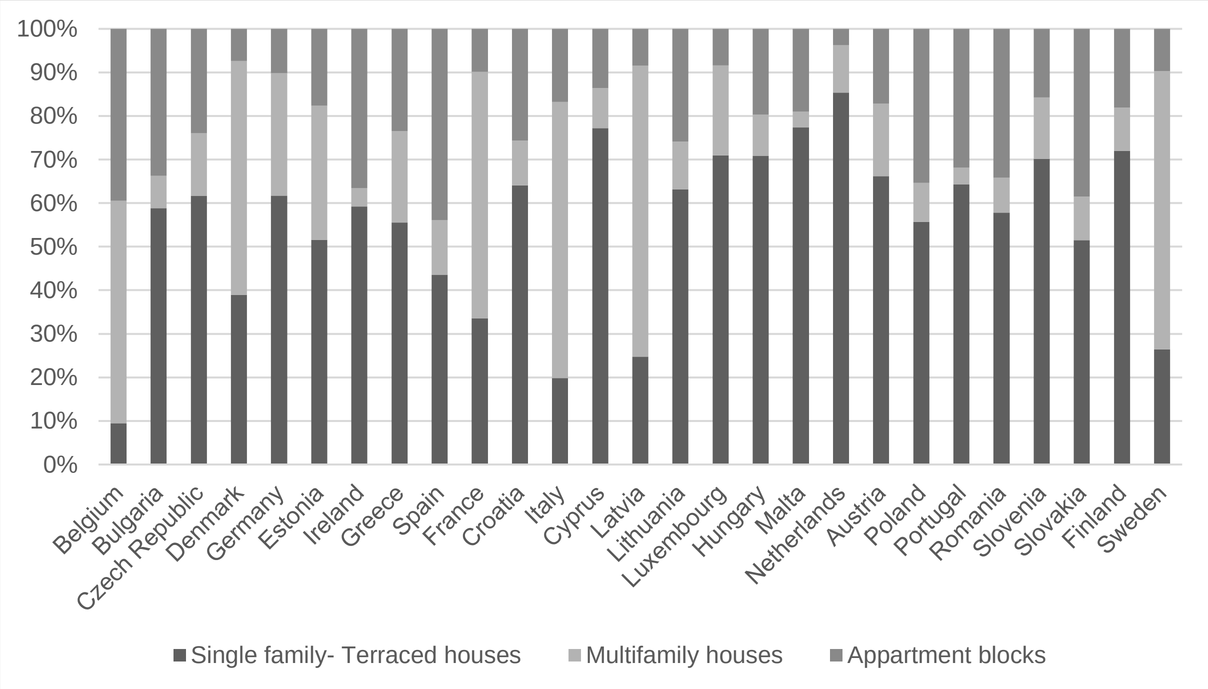
As a result of new construction and major renovations, in 2030 some 3.5 million parking spaces at residential buildings affected by the EPBD proposal are projected to be provided with pre-cabling. In the same year, the demand for EV recharging points at these buildings is forecasted at around 0.8-0.9 million. By 2050, 25 million parking spaces are expected to be pre-cabled, with a demand of 21-35 million recharging points.

As every parking space in buildings with more than three parking spaces must be pre-cabled, the long-term demand for recharging infrastructure is expected to be met. In the near future (2030), the number of parking spaces equipped with pre-cabling is projected to be well above the demand for recharging points. Above all, it ensures the future-proofing of buildings. By 2050, it is expected that almost all parking spaces equipped with pre-cabling will also have a recharging point.

However, the impact of the EPBD proposal on the provision of recharging infrastructure is fairly limited in the short term. In 2030, 2% of all residential buildings and 18% in 2050 fall within the scope of the EPBD proposal (see Figure 11)**Error! Reference source not found.Error! Reference source not found.**. If only multi-family buildings are considered, these percentages are 4% in 2030 and 36% in 2050.

Almost all newly constructed and renovated multi-family buildings (estimated at about 85%) are already within scope of the EBPD. Reducing the number of parking spaces in the EPBD proposal requirements in order to include more multi-family buildings will therefore yield little benefit. The largest gains can be achieved by bringing existing multi-family buildings within the scope of the EPBD. In 2030, existing multi-family buildings with more than three parking spaces that are not newly built or have not been renovated since 2027 are expected to account for about 94% of all multi-family buildings (in terms of total floor space). In 2050, this is estimated to be 57%. A considerable proportion of multi-family buildings - now and in the future - are not affected by the measures in the EPBD proposal. However, it is important to consider the practical issues involved in extending the scope to existing residential buildings.

Figure 13: Share of different types of residential houses in the total residential building stock, by country in Europe



Source: European Building Stock Database.

The impact of the proposed amendment to the EPBD is expected to differ from country to country due to the variation in types of residential buildings. For example, countries like Belgium, Bulgaria, Ireland, Spain, Poland and Romania have a relatively high share of multi-family buildings in their residential building stock. By contrast, countries such as Denmark, France, Latvia, Luxembourg, the Netherlands and Slovenia have a relatively low share (see Figure 13). In countries with a low proportion of multi-family buildings in the total building stock, the impact of the EPBD on the e-mobility market will be lower.

2.3.1.2 Office buildings

The provisions of the EPBD proposal for office buildings are outlined below.

Article 12(1) for new office buildings and office buildings undergoing major renovations with more than five parking spaces: pre-cabling for every parking space and one recharging point per two parking spaces

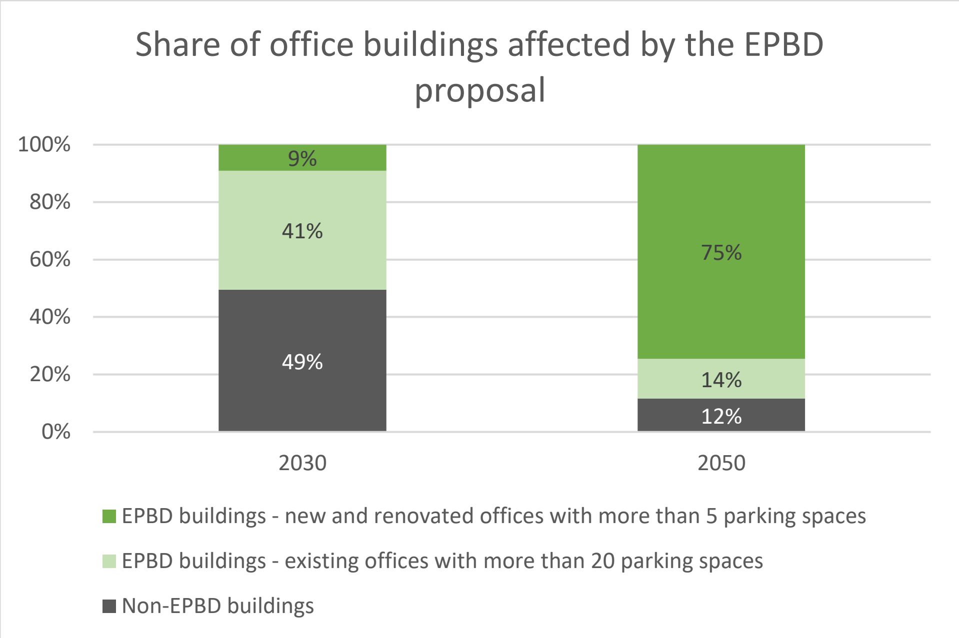
Article 12(2): for all buildings with more than 20 parking spaces: one recharging point per 10 parking spaces from 1 January 2027[147]

The requirements in the EPBD proposal differ for existing office buildings and for new and renovated office buildings. These categories have different demand and supply curves, making it useful to distinguish between them:

[147] Part of Article 12(2) specifically refers to buildings owned or occupied by public authorities, namely: 'all non-residential buildings with more than twenty parking spaces, in case of buildings owned or occupied by public authorities, Member States shall ensure pre-cabling for at least one in two parking spaces by 1 January 2033'. As this is only a limited share of the market, this item was not considered separately. To get an idea of the order of size: around 18% of employment in Europe is in the public sector (https://ec.europa.eu/eurostat/cache/digpub/european_economy/bloc-4d.html?lang=en).

- New and renovated offices with more than five parking spaces;
- Existing office buildings with more than 20 parking spaces.

Figure 14: Share of demand for recharging points in office buildings affected by EPBD proposal measures at a given moment, by building type

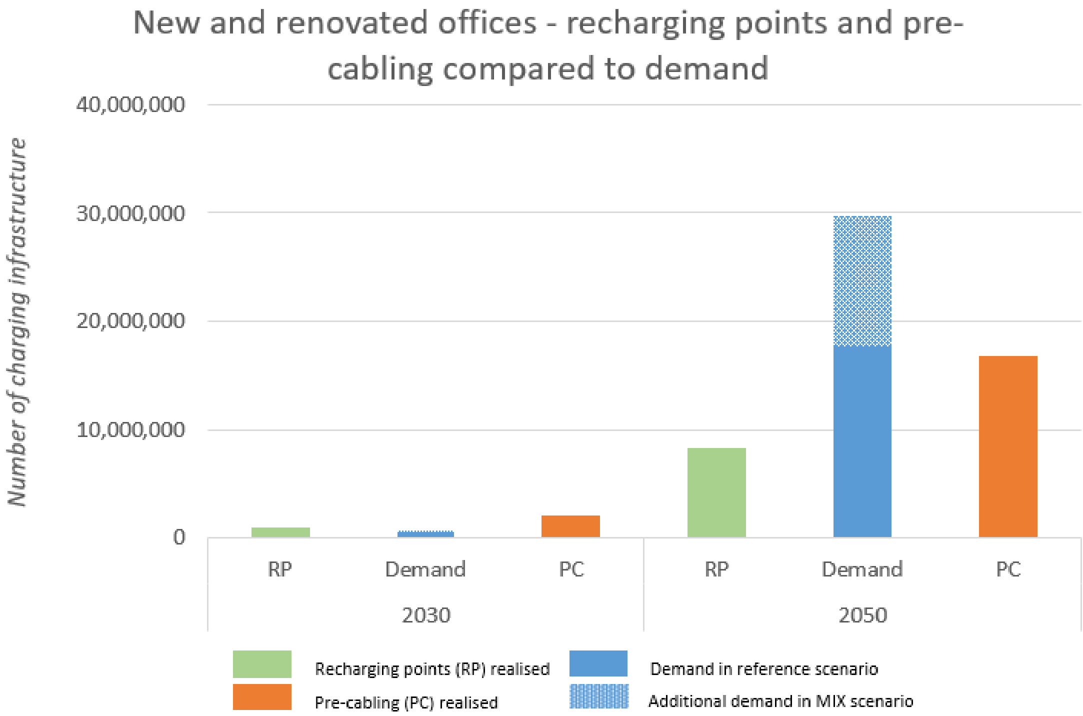


The scope of the EPBD proposal for office buildings is larger than for residential buildings because existing office buildings fall within the scope of the EPBD. In 2030, 9% of new and renovated offices and 41% of existing offices will be affected by the EPBD proposal, increasing to 75% and 14%, respectively, by 2050.

New and renovated offices with more than five parking spaces

If the demand for recharging points is compared with the supply of recharging points at the buildings affected by EPBD proposal measures, the following can be observed.

Figure 15: Comparison of supply and demand of recharging infrastructure in new and renovated office buildings within scope of the EPBD

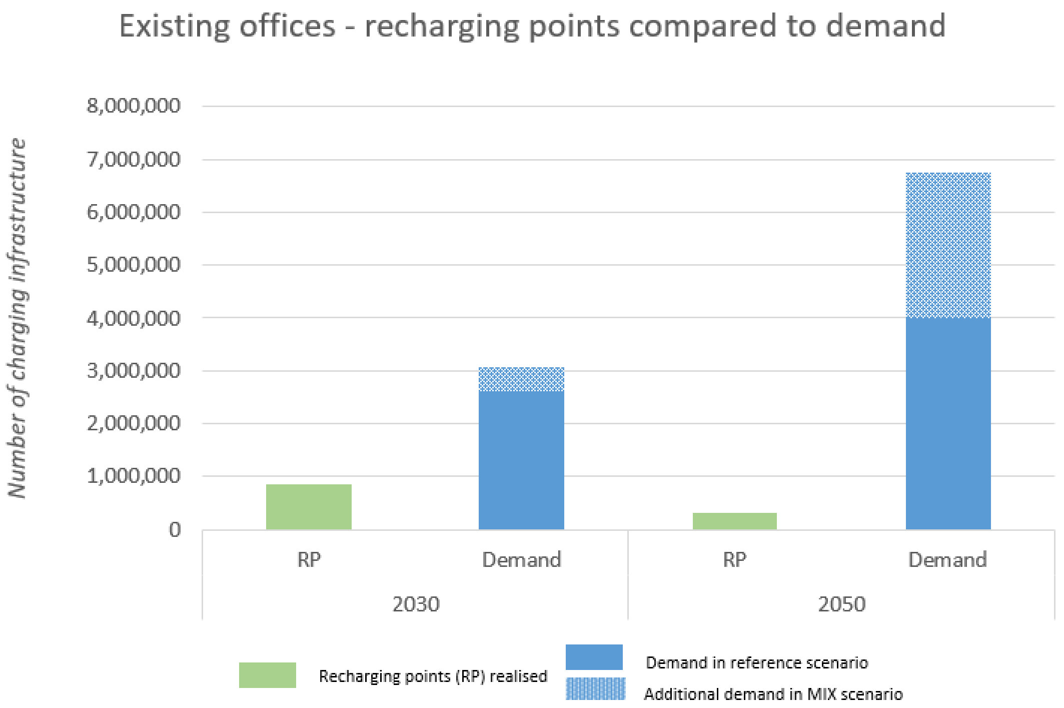


For new and renovated buildings within the scope of the EPBD proposal, in 2030, demand will be slightly below supply. While some 1.0 million recharging points are projected to be built, the demand is estimated to be 0.6-0.7 million. Some 2.0 million parking spaces should be equipped with pre-cabling (including the 1.0 parking spaces already equipped with a recharging point).

In 2050, the supply of recharging points is expected to fall below demand. Around 8.4 million recharging points are expected to be realized, compared to a demand of 18-30 million. In addition, another 8.4 million parking spaces are forecast to be provided with pre-cabling. In 2050, the demand for recharging infrastructure will exceed the number of parking spaces, implying a greater need for long-term public charging at offices during the day. Part of this demand can also be met by additional public recharging points at residential locations.

Existing office buildings with more than 20 parking spaces

Figure 16: Comparison of supply and demand of recharging infrastructure in existing office buildings within scope of the EPBD proposal



As a result of the less strict requirements in the EPBD proposal for existing offices compared to new and renovated offices, in 2030 the demand for recharging points at buildings affected by the EPBD proposal measure will be higher than the supply stimulated by the proposed EPBD measures. Around 0.9 million recharging points will be installed to meet a demand of around 2.6-3.0 million recharging points.

This shortage of recharging points is expected to increase by 2050. Although the share of existing offices in scope of the EPBD in the total building stock in 2050 is low, at 15% (see Figure 14), the demand will be greater than the number of recharging points, with around 0.3 million recharging points for this type of building, compared to a demand of 4.0-6.7 million recharging points.

A comparison between supply and demand for offices affected by the EPBD proposal's measures yields several conclusions:

- In the affected new and renovated offices, the number of recharging points exceeds the demand, especially in the early years. Although this will contribute to the uptake of electric cars, it requires investment in recharging infrastructure that will only pay off later on;
- The less strict requirements for existing offices compared to those for new and renovated offices means that in 2030, the supply of recharging points in existing offices is expected to be below demand. This gap between supply and demand is expected to increase by 2050 as a result of increasing EV use. Stricter requirements for existing offices therefore seem a realistic option - especially considering that in 2030, 41% of all offices affected by the EPBD proposal's measures are expected to be existing buildings (compared to the 9% that are new or renovated offices, see Figure 14). This building category therefore makes up a significant part of the total building stock.

2.3.1.3 Non-residential buildings, excluding offices

The provisions of the EPBD proposal for other non-residential buildings are described below.

Article 12(1): for new buildings and buildings undergoing major renovations with more than five parking spaces: pre-cabling for every parking space and one recharging point per building;

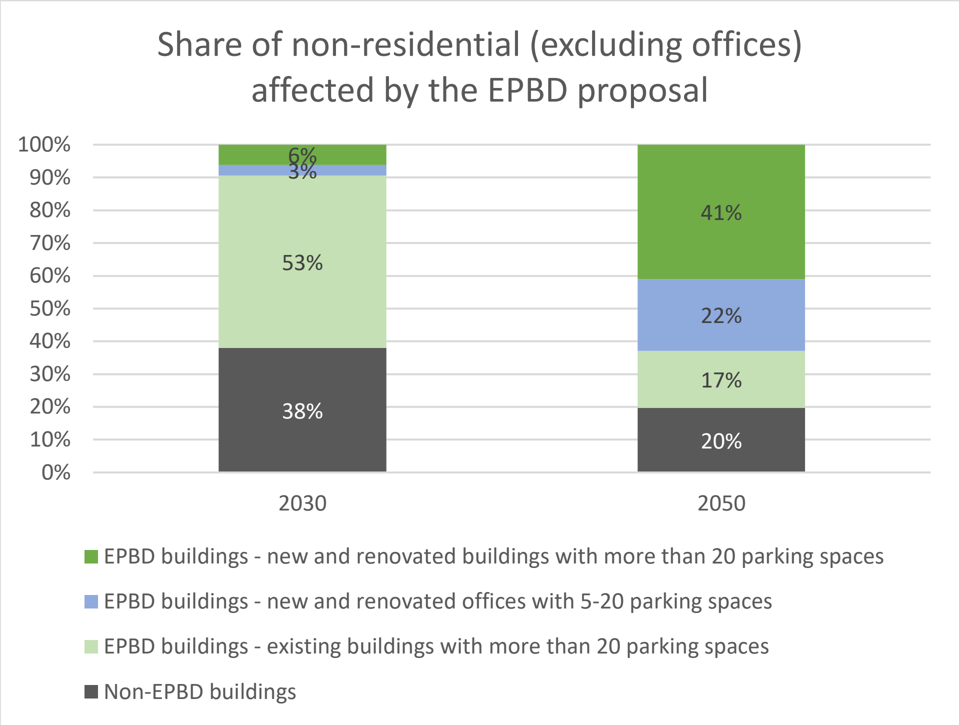
Article 12(2): for all buildings with more than 20 parking spaces: one recharging point per 10 parking spaces by 1 January 2027.

Other non-residential buildings require a different categorisation. This is because – assuming the most stringent requirement applies – new and renovated non-residential buildings (excluding offices) with more than 20 parking spaces fall under Article 12(1) for pre-cabling requirements and under Article 12(2) for recharging point requirements. For a proper comparison of supply and demand, a distinction must be made between three different building categories:

- New and renovated non-residential buildings (excluding offices) with more than five and less than 20 parking spaces;
- New and renovated non-residential buildings (excluding offices) with more than 20 parking spaces;
- Existing non-residential buildings (excluding offices) with more than 20 parking spaces.

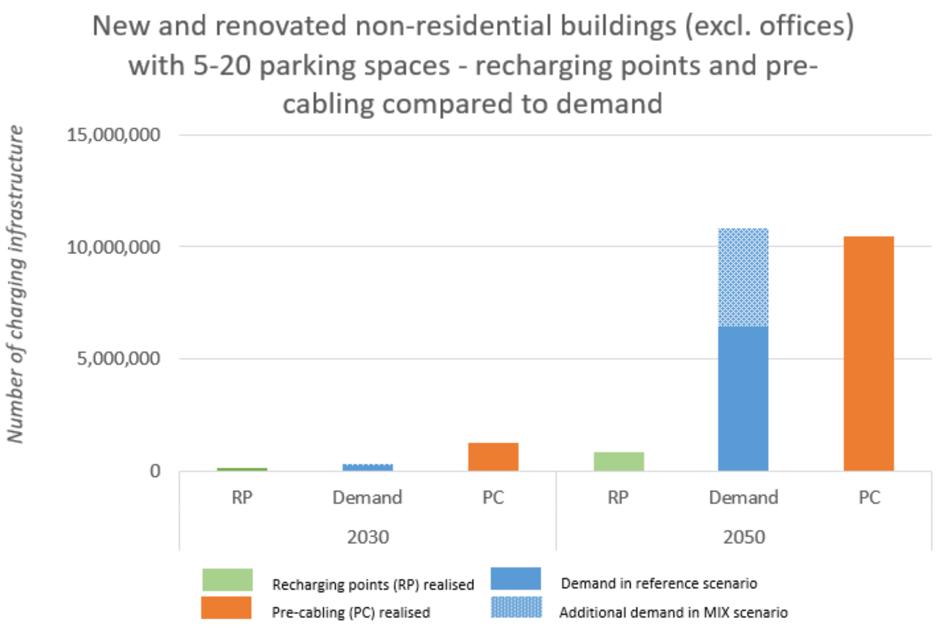
The share of other non-residential buildings affected by the EPBD measures is slightly higher than office buildings. In 2030, 62% of the total floor area of non-residential buildings (excluding offices) will be affected by the EPBD proposal measure. In 2050, as a result of new and renovated buildings, this share will have grown to an estimated 80%.

Figure 17: Share of demand for recharging points in non-residential buildings (excluding offices) affected by the EPBD proposal measures at a given moment, by building type



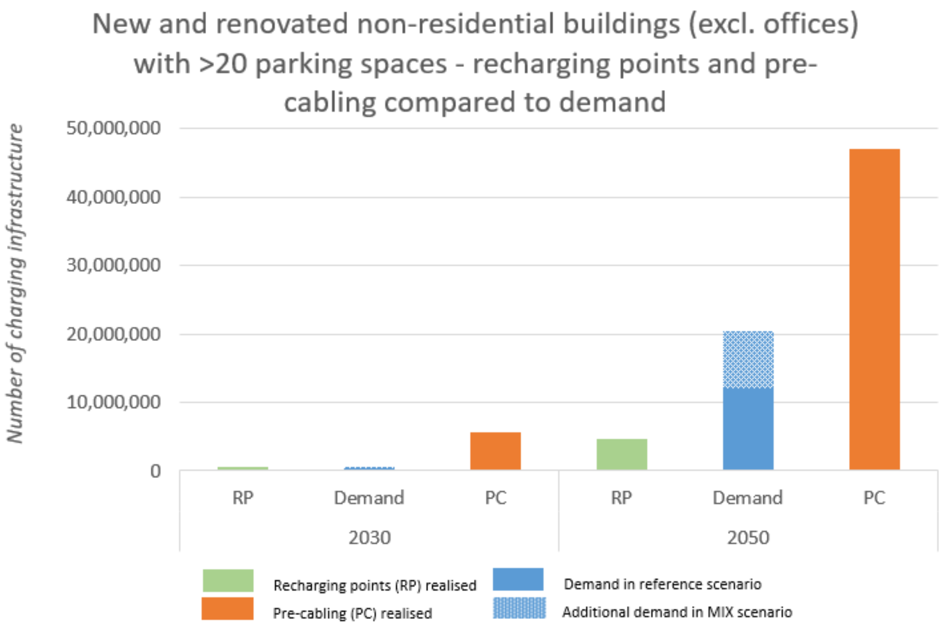
New and renovated non-residential buildings (excluding offices) with more than five and less than 20 parking spaces

Figure 18: Comparison of supply and demand for recharging infrastructure in new and renovated non-residential buildings within scope of the EPBD proposal (excluding offices) with more than five and less than 20 parking spaces



For this category of buildings, in 2030, the demand is estimated to be greater than supply: the implementation of the EPBD proposal is projected to realise 0.1 million recharging points, compared to a demand of 0.2-0.3 million recharging points. An additional 1.3 million parking spaces will be pre-cabled. By 2050, 0.8 million recharging points are projected to be installed to meet a demand of 6.5-10.8 million recharging points, with an additional 9.6 million pre-cabled parking spaces.

Figure 19: Comparison of supply and demand for recharging infrastructure in new and renovated non-residential buildings within scope of the EPBD proposal (excluding offices) with more than 20 parking spaces



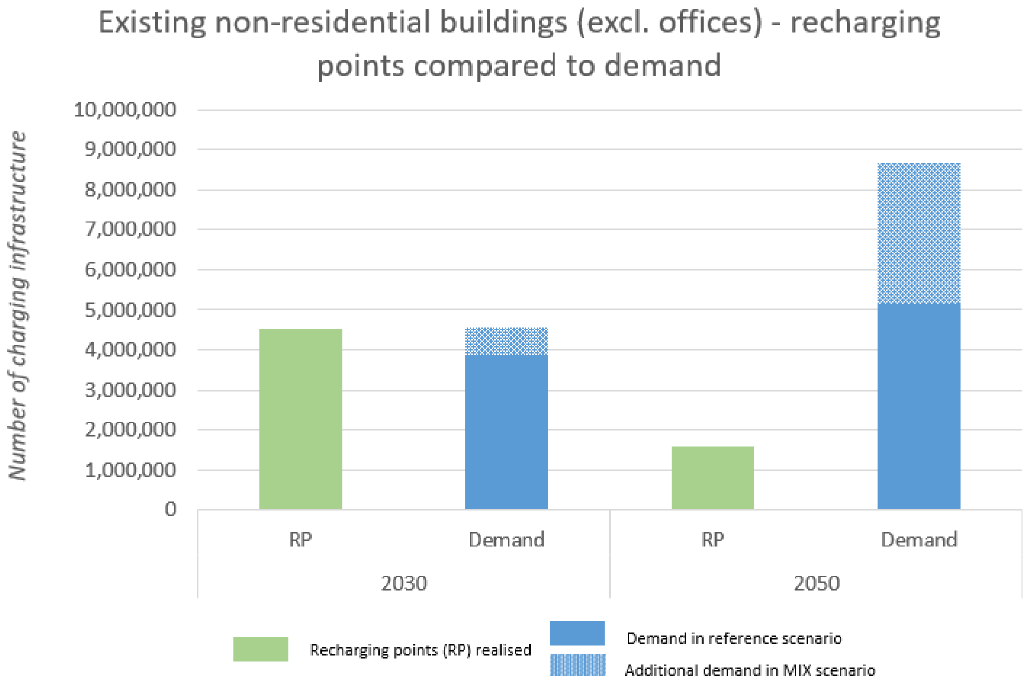
New and renovated non-residential buildings (excluding offices) with more than 20 parking spaces

For this category of buildings, in 2030, the estimated demand for recharging points will be almost equal to the supply stimulated by the proposed EPBD measures. Some 0.6 million recharging points are expected to be available as a result of the implementation of the EPBD proposal, compared to a demand of 0.5-0.6 million recharging points. In addition, 5.1 million parking spaces are expected to be pre-cabled.

In 2050, the EPBD proposal is projected to provide 4.7 million recharging points for this building category, against a demand of 12-20 million recharging points. Over 42 million parking spaces are expected to be pre-cabled by that time.

Existing non-residential buildings (excluding offices) with more than 20 parking spaces

Figure 20: Comparison of supply and demand for recharging infrastructure in existing non-residential buildings within scope of the EPBD proposal (excluding offices) with more than 20 parking spaces



In 2030, the demand for recharging points at the existing non-residential buildings (excluding offices) within scope of the EPBD proposal is projected to be almost equal to the supply stimulated by the proposed EPBD measures. An estimated 4.5 million recharging points will be installed in this category of buildings, compared to a demand of 3.9-4.5 million recharging points.

In 2050, the size of this building category is expected to have decreased, as more and more buildings will have undergone a major renovation and thus fall under different EPBD requirements. As a result, the supply of recharging points at existing non-residential buildings (excluding offices) in 2050 is estimated at 1.5 million, against a demand of 5.1-8.7 million.

In summary, no significant differences between supply and demand can be seen over the years for other new and renovated non-residential buildings (excluding offices). However, it is expected that by 2050 there will be a surplus of pre-cabled parking spaces as there will be no need for a recharging point for every parking space reserved for visitors. For the existing buildings, however, a shortage of recharging points is expected in 2050.

An additional advantage of recharging points at non-residential buildings is that they can be shared[148]. These parking spaces are mainly occupied during working hours, with the exception of company cars charged at the workplace overnight. Outside working hours, the parking spaces are unused and therefore offer the possibility to be used as a private recharging point for local residents. These locations have the option to serve residential buildings in the surrounding area with no access to private charging. This is especially relevant, as not having access to a private recharging point is a major obstacle to consumers purchasing an EV[149].

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[148] Huang, X., Long, X., Wang, J. and He, L., 'Research on parking sharing strategies considering user overtime parking', *PLOS ONE,* Vol. 16, No 5, 2021, e0251807.

[149] Plenter, F., Chasin, F., Von Hoffen, M., Betzing, J., Matzner, M. and Becker, J., ‚Assessment of peer-provider potentials to

2.3.2 Comparison of the EPBD proposal with the current EPBD

The requirements in the EPBD proposal are more stringent than in the current EPBD[150], and would bring more buildings within the scope of the EPBD. Table 14 shows the requirements in the current EPBD[151].

Table 14: Relevant e-mobility obligations under the current EPBD

Building type	Status	Scope	Requirements
Non-residential	Existing	> 20 parking spaces	• Member States shall lay down requirements for the installation of a minimum number of recharging points by 1 January 2025[152]
	New and major renovations	> 10 parking spaces	• Installation of at least one recharging point
		> 5 parking spaces	• Installation of ducting infrastructure for one in every five parking spaces
Residential	New and major renovations	> 10 parking spaces	Ducting infrastructure for every parking space

For residential buildings, the EPBD proposal will bring an estimated additional one-third of the total building stock (in sqm) of all multi-family buildings into the scope of the EPBD. While 57% of all multi-family buildings fall within its scope of the current EPBD (i.e. multi-family buildings with more than 10 parking spaces), the EPDB proposal will bring 91% of all family buildings into scope (i.e. multi-family buildings with more than three parking spaces). However, as the proposed EPBD measures only affect new and renovated residential buildings – which represent only a small share of the total affected residential buildings in the short term (2% of all residential buildings in 2030, or 4% if only multi-family buildings are considered, see Figure 11) – the impact of this scope expansion is limited until 2030.

Another difference is that the EPBD proposal specifically addresses pre-cabling, whereas the current EPBD refers to ducting infrastructure. The EPBD proposal will ensure 3.6 million parking spaces in residential buildings are provided with pre-cabling in 2030, compared to 2.4 million parking spaces provided with ducting infrastructure under the current EPBD. In 2050, this estimate increases to 29 million parking spaces, as opposed to 19 million under the current EPDB.

For non-residential buildings, the proposed EPBD is expected to bring more changes. Under the current EPBD, in 2030 there are a projected 2.6 million parking spaces with recharging points and 1.8 million with ducting infrastructure, increasing to 7.1 million parking spaces with recharging points and 9 million with pre-cabling under the EPDB proposal. In 2050, the EPBD proposal is expected to provide non-residential buildings with 16 million recharging points and 74 million pre-cabled parking spaces, compared to 5 million recharging points and 15 million parking spaces with ducting infrastructure under the current EPBD. The impact on offices is

share private electric vehicle charging stations' *Transportation Research Part D: Transport and Environment*, Vol. 64, 2018, pp. 178-191.

[150] Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings.

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

[152] The analysis in the next chapter showed that this specific paragraph from the current EPBD is generally transposed by Member States as 'a minimum of one charging point per building'. This was taken as a starting point for the comparison.

particularly significant: the EPBD proposal provides four times more recharging points in offices than the current EPBD. It also doubles the amount for non-residential buildings.

In total, the EPBD proposal is projected to provide 11 million additional recharging points and 69 million additional parking spaces equipped with pre-cabling by 2050, compared to the current EPBD.

2.3.3 Discussion

The analysis revealed a number of other considerations that are relevant in interpreting the results.

Differences in rural and urban areas

Rural areas have more parking spaces per sqm of building compared to urban areas, due to the greater availability of space. Although car ownership is higher in rural areas[153] and longer distances are covered - and therefore more use is made of cars[154] - parking norms per unit floor area are higher in rural areas, even when taking the higher car usage in rural areas into account.

In general, parking norms in European rural areas are higher than in urban areas[155]. In the Netherlands, for example, parking norms for residential buildings in rural areas are about twice as high as for dense urban areas. For non-residential buildings, parking norms in rural areas are almost three times higher[156]. The same is true in the UK[157].

Currently, the EV usage per capita is higher in urban areas than in rural areas. The share of new registrations per capita is almost twice as high in urban areas, with 15 EV registrations per 10,000 inhabitants compared to seven EV registrations per 10,000 inhabitants in rural areas[158]. The share of new M1 registrations is also higher, at 4.0% in urban areas and 2.9% in rural areas[159]. Nevertheless, this difference is expected to disappear in the long term, as the use of EVs increases in society generally.

Rural areas are well suited for EV use due to the high proportion of single-family houses and the possibility of home charging[160]. ACEA[161] estimates that by 2021, 58% of EV drivers in urban areas will have access to home charging, compared to 83% in rural areas. By 2030, it is expected that 38% of EV drivers in cities will have access to home charging, compared to 68% in rural areas. There will be higher demand for fast-charging along highways in rural areas, as the greater average distances travelled by car require more on-the-go charging[162].

Differences for different types of non-residential buildings

Different types of locations attract different types of EV users, impacting the need for recharging infrastructure. Employees, for example, often have their car parked at the

[153] In the EU, there is around 0.6 car per adult for urban areas, compared to 0.8 car per adult in rural areas (Fiorello, D., Martino, A., Zani, L., Christidis, P. and Navajas-Cawood, E., 'Mobility data across the EU 28 Member States: results from an Extensive CAWI Survey', *Transportation Research Procedia*, Vol. 14, 2016, pp. 1104-1113.
[154] Scheiner, J., 'A century of motorisation in urban and rural contexts: paths of motorisation in German cities', *Erdkunde*, 2012, pp. 313-328.
[155] Gies, J., Hertel, M. and Tully, S., Parking standards as a steering instrument in urban mobility planning. PARK4SUMP project, 2020.
[156] CROW, 'Aanbeveling voor verkeersvoorzieningen binnen de bebouwde kom', CROW, Ede, 2012.
[157] Buckinghamshire County Council Transport, Economy and Environment, Buckinghamshire Countrywide Parking Guidance, 2015.
[158] Wappelhorst, S., 'Beyond major cities: Analysis of electric passenger car uptake in European rural regions', International Council on Clean Transportation, working paper, 2021-10, 2021.
[159] Ibid.
[160] Ibid.
[161] ACEA, European EV Charging Infrastructure Masterplan, 2022.
[162] Wappelhorst, S., 'Beyond major cities: Analysis of electric passenger car uptake in European rural regions', International Council on Clean Transportation, working paper, 2021-10, 2021.

workplace all day, while visitors generally only park at a location during the visiting period. The average dwell time of visitors differs depending on the type of destination.

In general, destinations with a high share of visitors and a low average dwell time have a lower demand for recharging infrastructure per parking space. Restaurants, hotels, sports facilities and wholesale and retail locations (e.g. supermarkets, DIY stores, shopping centres) have a high proportion of parking spaces dedicated to visitors compared to hospitals, primary schools and universities (see Table 15). In addition, shopping centres and universities have a longer average dwell time of visitors than supermarkets or hospitals.

Table 15: Proportion of parking spaces reserved for visitors for various types of destination

	Share of parking spaces dedicated to visitors
Offices	5%
Wholesale and retail	90%
Sports facilities	90%
Hotels	73%
Restaurants	80%
Hospitals	29%
Dentists	47%
Primary schools	10%
Universities	48%

On average, people spend longer on the road for certain activities than others. For example, as there are fewer hospitals than supermarkets, the average distance travelled to hospitals is longer. The longer the distance travelled to a destination, the greater the chance that the EV user will use the recharging point at the destination.

It is therefore expected that non-residential buildings with a high share of visitors, a low average duration of stay, and a small catchment area will have a lower demand for recharging infrastructure per parking space.

Impact of the Renovation Wave Strategy on the EPBD

Most of the stimuli to install recharging infrastructure are realised under the proposed EPBD paragraphs that apply to new and majorly renovated buildings. Under these paragraphs, approximately one-third of the recharging infrastructure will be realised in new buildings and two-thirds in renovated buildings.

This is based on the assumption that the annual major renovation rate is 1.5% for residential buildings and 2.7% for non-residential buildings. These percentages assume the implementation of the Renovation Wave Strategy[163] (i.e. the doubling of the annual energy renovation rate of residential and non-residential buildings by 2030 and beyond).

If the Member States only partially implement the Renovation Wave Strategy, this is expected to have a negative impact on the recharging infrastructure realised under the EPBD proposal.

For residential buildings, non-implementation of the Renovation Wave Strategy means that in 2030, 1.1 million fewer parking spaces will be equipped with pre-cabling (33% decrease compared to full implementation). In 2050, that reduction would rise to 9.5 million (33% decrease).

For non-residential buildings, non-implementation in 2030 would mean 0.7 million fewer parking spaces equipped with recharging points (decrease of 10%) and 3.0 million fewer parking spaces provided by pre-cabling (decrease of 33%). In 2050, this figure would rise to 2.5 million fewer recharging points (16% decrease) and 24 million fewer pre-cabled parking spaces (33% decrease).

Limited implementation of the Renovation Wave Strategy thus risks excluding a significant proportion of buildings, limiting the impact of the EPBD on the e-mobility market. Implementation of the Renovation Wave Strategy thus plays a key role in the impact of the EBPD.

Data availability and recommendations for future research on the impact of the EPBD

Despite the fact that parking spaces can be found on almost every corner in Europe, the number of reliable datasets on parking spaces in Europe is limited. Due to the lack of information, empirical research should be included in follow-up research, for example in the evaluation of the EPBD. This will enable a better understanding of the number of parking spaces for different types of buildings.

Another option would be to require Member States to report on the implementation of the EPBD and to provide insight into the amount of recharging infrastructure that has been realised, and in which types of buildings. Future research should also consider the differences between countries, given the differences in building stock compositions, levels of EV adoption, and parking norms.

[163] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, *A Renovation Wave for Europe - greening our buildings, creating jobs, improving lives*, SWD(2020) 550, Brussels, 14.10.2020.

3 ANALYSIS OF LEGAL AND POLICY MEASURES ON E-MOBILITY IN BUILDINGS

Main findings

Transposition of EPBD provisions on new buildings or buildings undergoing major renovations (Article 8(2) and Article 8(5)

No transposition in two Member States, but legal texts planned;

Transposition ‘a minima’ in the vast majority of Member States;

Few Member States have adopted more stringent measures on

Parking space thresholds triggering recharging points and/or ducting infrastructure obligations;

Recharging points and ducting infrastructures (e.g. higher rate/number of charging points per parking space, specific requirements on types of chargers and capacity, pre-cabling requirements).

Minimum number of recharging points set by national legislation for all non-residential buildings with more than 20 parking spaces, by 2025

Not transposed or transposed with narrower scope in several Member States;

Transposition ‘a minima’ in the majority of Member States;

Few Member States apply an earlier deadline (i.e. 2023 or 2024);

Few Member States have set more stringent requirements on the number of recharging points to be installed or ducting infrastructure.

Derogations to EPBD provisions on e-mobility

The derogation relating to small and medium-sized enterprises (SMEs) (Article 8(4) EPBD) is only transposed in a small number of countries, and in several cases only as a delegation of power that has yet to be exercised;

Exemptions for specific buildings (Article 8(6) EPBD): by far the most common exemption relates to costs exceeding 7% of the costs of the building or major renovation.

Additional requirements on e-mobility in buildings not linked to the EPBD

Fire safety measures are in place or being considered in several countries;

Requirements on bicycle parking spaces in five countries;

In the UK (England, Wales, Scotland) all charging points sold - other than public charging points, non-smart cables, and rapid charging points - must have smart recharging functionality.

This analysis is based on desk research and interviews with competent authorities. That research was carried out by a network of national legal experts through the completion of country fiches in all EEA countries and the UK to provide up-to-date information on current and proposed legal and policy measures to support the uptake of recharging points in buildings. It provides an overview of the transposition – or reflection – of the provisions of Article 8 of the current EPBD (e.g. a minima transposition, transposing measures that go beyond the EPDB, use of exemptions) and identifies additional measures on e-mobility in buildings not linked to the EPBD.

3.1 Rules on new non-residential buildings and non-residential buildings undergoing major renovation

Article 8(2) of the EPBD

With regard to new non-residential buildings and non-residential buildings undergoing major renovation, with more than 10 parking spaces, Member States shall ensure the installation of at least one recharging point within the meaning of Directive 2014/94/EU of the European Parliament and of the Council (1) and ducting infrastructure, namely conduits for electric cables, for at least one in every five parking spaces to enable the installation at a later stage of recharging points for electric vehicles where:

(a) the car park is located inside the building, and, for major renovations, renovation measures include the car park or the electrical infrastructure of the building; or

(b) the car park is physically adjacent to the building, and, for major renovations, renovation measures include the car park or the electrical infrastructure of the car park.

The paragraphs below detail how Article 8(2) of the EPBD was transposed in Member States, as well as the extent to which the **Iceland, Norway and the UK** adopted similar provisions. It identifies whether the article was transposed or reflected 'a minima', or whether the countries adopted transposing measures that go beyond EPBD requirements (e.g. on the type of non-residential buildings covered, parking space thresholds, recharging points, ducting infrastructure obligations).

Transposing measures planned

Spain has not yet transposed this EPBD provision. A draft bill[164] has been published requiring that new non-residential buildings and non-residential buildings undergoing major renovation must have:

- Cable conduit systems installed to allow for the future installation of recharging stations for at least 20% of the parking spaces;
- One recharging station for every 40 parking spaces, and at least one station;
- In buildings for use other than private residential use that are owned by the General State Administration or its linked/dependent public bodies, a recharging station shall be installed for every 20 parking spaces.

Latvia only requires that by 1 January 2025, at least one recharging point for EVs shall be installed in each public building with more than 20 car parking spaces, without any specific requirements for new non-residential buildings. A 'public building' is defined in Latvian law as a building in which more than 50% of the total area of the building is a public premise or premises for the provision of a public function, or an engineering structure intended for public use (e.g. stages, stadiums)[165]. According to interviewees, a new law is planned to set out new e-mobility requirements in residential and non-residential buildings.

No similar measures in UK (Wales, Scotland, Northern Ireland)

In the **UK,** e-mobility in buildings is under the competence of the four constituent countries, and Wales, Scotland and Northern Ireland have not adopted similar measures. In Scotland, some changes to the Scottish Building Regulations are under consultation, including: buildings

[164] Draft Royal Decree amending the Technical Building Code (CTE), available at: https://www.mitma.gob.es/el-ministerio/buscador-participacion-publica/proyecto-de-real-decreto-por-el-que-se-modifica-el-codigo-tecnico-de-la-edificacion-aprobado-por-real-decreto-3142006-de-17-de-marzo

[165] Cabinet of Ministers Regulations No. 693 'General requirements for standard for buildings LBN 200-21' (*Ministru kabineta noteikumi Nr. 693 'Būvju vispārīgo prasību būvnormatīvs LBN 200-21'*), Latvijas Vēstnesis, 204, 21.10.2021.OP numurs: 2021/204.3, available at: https://likumi.lv/ta/id/326992-buvju-visparigo-prasibu-buvnormativs-lbn-200-21

with more than 10 non-residential car parking spaces must install ducting for one in every two non-residential parking spaces and must install an EV charging socket for one in every 10 non-residential parking spaces (minimum 7 kW output power rating).

A minima transposition

This EPBD provision was transposed 'a minima' in several countries (AT[166], BE-Wallonia), CZ, CY, EE, HR, DK, EL, FR, HU, IE, IT, MT, NL, PL, RO, SK, SE). In other words, these Member States have not adopted transposing measures that go beyond the EPBD requirements. In the UK, England has measures equivalent to Article 8(2) of the EPBD.

More stringent parking space thresholds related to charging points and/or ducting infrastructure obligations

Some countries (DE, LT, LU, PT and IS) have adopted more stringent buildings' parking space thresholds to trigger the obligations to install a charging point and ducting infrastructure.

In **Germany**, these obligations apply to new non-residential buildings with more than six parking spaces within the building or more than six parking spaces adjacent to the building. For non-residential buildings undergoing major renovations, the threshold is the same as the current EPBD (i.e. more than 10 parking spaces).

In **Lithuania**, these obligations apply to new buildings or buildings undergoing reconstruction, renovation (modernisation) or major renovation, with five or more parking spaces. It also applies to the reconstruction or renovation of open car parks (five or more parking spaces) of non-residential buildings and their electrical grid infrastructure.

In **Portugal**, there is no such parking spaces threshold. Any new non-residential building or building undergoing major renovations must have at least two charging points and ensure the conditions for future EV charging infrastructure (ducts and cable trays) for one in five parking spaces.

In **Luxembourg**, there is no threshold for ducting infrastructure. For new non-residential buildings or buildings undergoing major renovation, indoor parking spaces and outdoor spaces must be designed and equipped so as to accommodate a charging device for EVs or PHEVs.

Bulgaria sets different thresholds based on the type of non-residential building, which apply to both new and existing buildings. The share of parking spaces for EVs is given as a percentage of the total number of parking spaces and varies from 3% for buildings for children's activities to 20% for airports. In most cases the share is 5% (e.g. buildings for social services, roadside buildings and sports facilities without audience capacity), 10% (e.g. student dormitories, shops and markets, sport facilities with audience capacity, medical institutions, universities) and 15% (e.g. public administration buildings, cultural buildings, shopping centres, industrial buildings, petrol/gas stations and transport buildings – railway, bus and river stations).

France requires that at least 2% of ducted parking places (and at least one in any case) should be accessible for persons with reduced mobility.

Iceland's legislation sets a scale for the number of charging points and/or ducting required in relation to the total number of parking spaces. There must be at least one charging point and/or ducting in new non-residential buildings with between one and five parking spaces.

In **Norway**, the legislation states that where parking places are required under the Planning and Building Act, they must include the installation of conduit cables and sufficient space for electrical infrastructure for charging systems for EVs. The obligation applies to all newly

[166] All Länder except Niederösterreich, Steiermark and Wien have transposed a minima this provision of the EPBD.

installed parking places that fall within that category, irrespective of whether the parking place is separate or adjunct to the building.

More stringent/detailed provisions on charging points and ducting infrastructure

In Niederösterreich Länder in **Austria**, new non-residential buildings or those undergoing major renovations, with publicly accessible parking spaces and in other public parking areas, with at least 10 obligatory parking spaces must have at least one recharging point per each quota of 25 obligatory parking spaces.

In Steiermark Länder in **Austria**, new constructions and major renovations of certain buildings (care homes, offices and administrative buildings, shops and event centres, restaurants and hotels, hospitals, schools, universities, commercial and industrial buildings,) as well as construction of other publicly accessible parking areas, with at least 10 parking spaces, must have at least one recharging point per each start of a quota of 25 parking spaces.

In Wien Länder in **Austria**, new non-residential buildings and non-residential buildings undergoing major renovation, with more than 10 parking spaces, must have one recharging point for every 10 parking spaces.

In **Bulgaria**, new non-residential buildings with more than 10 parking spaces and non-residential buildings ongoing major reconstruction, must have at least 1 in 10 parking spaces equipped with a recharging point with large power (capacity for charging EVs with power >22 kW) and the rest are equipped with normal power (capacity for charging EVs with power of 3.7-22 kW).

In **Belgium-Flanders**, non-residential buildings and parking buildings, whether new or existing and subject to substantial renovation, that have a parking area with more than 10 parking spaces, must have at least two normal or high-power charging points for EVs, as well as ducting infrastructure, or at least ducts for electric cables, for at least one in four parking spaces.

In **Belgium-Brussels Capital,** new car parks (with more than 10 parking spaces) residential and non-residential at least one charging point and the adequate ducting for future installation of charging points for each parking space.

In **Germany,** a new non-residential building with more than six parking spaces within or adjacent to the building must have at least every third parking space equipped with the cable infrastructure for e-mobility.

In **Lithuania**, in new non-residential buildings or those under reconstruction, renovation (modernisation) or major renovation, at least 20% of the total number of parking spaces (five or more parking spaces) must be 'available'[167] for charging EVs.

In **Luxembourg**, in new or undergoing major renovation non-residential buildings, every fourth parking space (at least one parking space if there are less than four spaces in total) must have suitable pre-cabling or two conduits, depending on the planned cabling. One of these conduits must be able to accommodate an electrical cable leading to the main distribution board and the other conduit must be able to accommodate a cable for the transmission of data leading to the metering cabinet or to the location of the charging power management system. For new non-residential buildings or those undergoing major renovation, with more than 20 parking spaces, at least three in 20 spaces must have a charging point.

In **Finland**, new non-residential buildings and non-residential buildings undergoing major renovation, with more than 10 parking spaces must have one high-capacity charging point per parking area. Alternatively, they may have: for 11-50 parking spaces - at least one charging

[167] 'Available' is taken to mean that they are equipped with a charging point.

point with normal capacity; for 51-100 parking spaces – at least two charging points with normal capacity; more than 100 parking spaces – at least three normal-capacity charging points.

A new building other than a residential building, with 11-30 parking spaces, must have charging point readiness (ducting or cabling) installed in at least 50% of the parking spaces. However, if there are more than 30 parking spaces, at least 20% of the parking spaces must be equipped with charging point readiness (ducting or cabling), with a minimum of 15 parking spaces. If a charging point is installed in the parking space, it meets the requirement for the parking space to be equipped with charging readiness.

In **Iceland**, the legislation sets a scale for the number of charging points and/or ducting required in relation to the total number of parking spaces:

- 1-5 parking spaces: at least one parking space with recharging point and/or ducting;
- 6-10 parking spaces: at least two parking spaces with recharging points and/or ducting;
- 11-15 parking spaces: at least three parking spaces with recharging points and/or ducting;
- 16-20 parking spaces: at least four parking spaces with recharging points and/or ducting.

No specific requirements on pre-cabling were identified, except in Luxembourg. The national laws do not clearly define or differentiate between ducting and pre-cabling requirements.

In **Slovenia,** in addition to the EPBD requirement on ducting infrastructure, the national law requires that such infrastructure enables simultaneous charging of EVs in all parking spaces[168].

In **Norway,** all newly installed parking places must include the installation of conduit cables and sufficient space for electrical infrastructure for charging systems for EVs.

3.2 Rules on new residential buildings and residential buildings undergoing major renovations

Article 8(5) of the EPBD

With regard to new residential buildings and residential buildings undergoing major renovation, with more than 10 parking spaces, Member States shall ensure the installation of ducting infrastructure, namely conduits for electric cables, for every parking space to enable the installation, at a later stage, of recharging points for electric vehicles, where:

(a) the car park is located inside the building, and, for major renovations, renovation measures include the car park or the electric infrastructure of the building; or

(b) the car park is physically adjacent to the building, and, for major renovations, renovation measures include the car park or the electrical infrastructure of the car park.

This sub-section describes how Article 8(5) of the EPBD was transposed in Member States and reflected in provisions in **Iceland, Norway** and the UK. In particular, it identifies whether this article was transposed or reflected 'a minima' in Member States and IS, NO, UK legislation, and if any country adopted measures that went beyond the EPDB requirements.

[168] The interviewee from NCA explained that although ducting infrastructure must be enabled for at least one in five parking spaces, it must be provided so as to enable future simultaneous charging of vehicles in all parking spaces.

Transposing measures planned

At the time of writing, **Spain** has yet to transpose this EPBD provision. A draft bill[169] has been published that requires any new residential buildings and existing residential buildings with some interventions[170] to install cable conduit systems to allow for the future installation of recharging stations for 100% of the parking spaces.

Latvia only requires that by 1 January 2025, at least one recharging point for EVs shall be installed in each public building with more than 20 car parking spaces. However, a law is being planned to address the EPBD requirements.

No requirements exist in **UK-Wales, Northern Ireland, Scotland**. Some changes to the Scottish Building Regulations are under consultation, including:

- New residential buildings with a parking space must have at least one EV charging point socket with minimum 7 kW output power rating**,** with an exemption if the additional cost of electricity grid connection exceeds GBP 2,000. In case of application of the exemption, ducting infrastructure must be installed in each car parking space;
- Residential buildings undergoing major renovation, with more than 10 car parking spaces, must have ducting installed in each residential car parking space to support the future installation of an EV charging point. EV charging points sockets must be installed, with minimum 7 kW output power rating, in as many residential car parking spaces as the electrical capacity of the building post-renovation allows. An exemption applies if the cost of installing recharging and ducting infrastructure exceeds 7% of the total major renovation cost.

A minima transposition

This EPBD provision was transposed ‘a minima’ in several countries (AT[171], CZ, DK, EE, IE, EL, FR, HR, IT, HU, MT, PL, NL, SI, SK, SE). In other words, these Member States have not adopted transposing measures that go beyond the Directive’s requirements.

Transposing measures that go beyond the EPBD requirements

In Burgenland in Austria, there is no parking space threshold, and a new construction of a residential building with parking spaces must have ducting infrastructures installed. This is the same approach in Luxembourg and Portugal, as well as Iceland and the UK.

In Luxembourg, indoor and outdoor parking spaces in new residential buildings or in buildings undergoing major renovations must be designed and equipped so as to be able to subsequently accommodate a charging device for EVs or PHEVs. Each parking space must have appropriate pre-wiring or two conduits, depending on the planned wiring concept. One of these conduits must be able to later accommodate an electrical cable leading to the main distribution board and the other conduit must be able to accommodate a cable for the transmission of data leading to the metering cabinet or to the location of the charging power management system. For multi-family dwellings[172]:

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[169] Draft Royal Decree amending the Technical Building Code (CTE), available at: https://www.mitma.gob.es/el-ministerio/buscador-participacion-publica/proyecto-de-real-decreto-por-el-que-se-modifica-el-codigo-tecnico-de-la-edificacion-aprobado-por-real-decreto-3142006-de-17-de-marzo

[170] Interventions on the electrical installation of the building affecting more than 50% of the power installed in the building before the intervention, for those cases in which the parking lot is located inside the building, provided that there is a right to act on the car park by the person carrying out the intervention; interventions in the electrical installation of the car park that affect more than 50% of the installed power of the car park; extensions, in those cases in which interventions in the car park are included and an increase of more than 10% of the built area or the built volume of the unit or units of use on which the work is carried out, and where the total useful area enlarged exceeds 50 m^2; changes in the characteristic use of the building; alterations involving interventions on the car park and in which more than 25% of the total surface area of the final thermal enclosure of the building is renovated.

[171] Apart Burgenland.

[172] Apartment buildings, second home apartment buildings and semi-detached apartment buildings.

- Additional prewiring or conduit for laying a cable for data transmission is to be provided between the termination point of a public communication network operator and the switchboard of the main distribution, or the location of the collective intelligent load management system.
- A collective intelligent load management system must be installed. This system manages all of the charging points behind the same connection point to limit the simultaneous withdrawal of power to a value that cannot exceed the capacity made available by the network manager at the connection point and must be able to integrate a number of charging points equivalent to the number of locations located inside/outside the building and must allow non-discriminatory connection of future users.

Depending on the chosen wiring concept, the main distribution board or, if applicable, the individual outgoing boards must have free space to be able to subsequently accommodate additional protective devices for the connection of the devices dump.

In Portugal, residential buildings that are new or undergoing major renovation must have charging infrastructure, including ducts and cable trays, for all parking spaces.

In Iceland, all parking spaces belonging to new residential buildings and residential buildings undergoing major renovation must be fitted with recharging points and/or ducting. This applies to all parking spaces, whether they are above ground, underground or in a garage.

In the UK (England), new residential buildings with associated parking must have at least as many charge points as there are dwellings, and for each parking space, if the number of parking spaces is less than the number of dwellings. This only applies up to the point where the average cost of installation per vehicle charging point does not exceed GBP 3,600. Once this cap is exceeded, cable routes must be installed for every parking space where a charging point would otherwise be installed. In addition, cable routes for a charging point are required for all parking spaces where a charging point is not installed if the building has more than 10 parking spaces and more parking spaces than dwellings. If the building has a covered parking area, the requirements must be preferentially applied to the non-covered parking if any parking spaces are outside of the covered parking. If the number of non-covered parking spaces are not sufficient to meet the requirements, additional cable routes must be installed in enough covered parking spaces to cover a total number of parking spaces equivalent to the number of dwellings, where there are fewer than 10 parking spaces in total, or in all covered parking spaces if there are fewer total parking spaces than the number of dwellings, or the total number of parking spaces exceeds 10. Residential buildings undergoing major renovation and that will have more than 10 parking spaces within the site boundary after the renovation must have at least one associated parking space for the use of each dwelling, with access to an EV charging point, and cable routes must be installed in all additional associated parking spaces. These requirements apply if:

- The renovation includes work on a car park within the boundaries of the building site, where the nature of the work makes it reasonable for it to cover these requirements, or the electrical infrastructure of a car park is located inside the building or the boundaries of the building site;
- The building will have more than 10 associated parking spaces at the end of the work;
- All required charging points can be accommodated in the electrical supply of the building. If this is not the case, the charging point requirements apply up to the maximum number of charging points the electrical supply can accommodate, and cable routes must be installed for all remaining associated parking spaces;
- The cost of meeting the requirements does not exceed 7% of the total cost of the renovation;

- The principal purpose of the major renovation is not to improve the fire safety of the external walls or roof of the building.

In Cyprus and Finland, ducting infrastructure (or cabling in Finland) must be installed in residential buildings (new buildings or buildings undergoing major renovation) with more than two parking spaces and four parking spaces, respectively. Similarly, in Belgium-Flanders, the applicability threshold is two or more parking spaces for new residential buildings. The Article 8(5) threshold applies to residential buildings undergoing major renovations.

In Lithuania, the threshold is five or more parking spaces for new buildings or buildings undergoing major renovation. This requirement also applies to the reconstruction or renovation of open car parks (five or more parking spaces) of non-residential buildings and their electrical grid infrastructure. In such cases, at least 20% of total parking spaces must be available for charging EVs. The remaining parking spaces in the car storage facility shall be equipped with electrical grid infrastructure (electrical ducts with electrical cables) to allow charging of EVs when needed.

German legislation has different applicability thresholds for new buildings (five parking spaces) and those undergoing major renovation (10 parking spaces). If a new building is mixed-use, but its use as residential building predominates, the provisions relating to residential buildings apply.

Other approaches compared to Article 8(5) of the EPBD

In Bulgaria, in new residential buildings and residential buildings undergoing major renovations with more than 10 parking spaces, the share of parking spaces for EVs is 10% of the total number of parking spaces. It is unclear whether this relates to charging points or ducting infrastructures.

In Norway, any parking place, as defined by law, must include the installation of conduit cables and sufficient space for electrical infrastructure for charging systems for EVs. The obligation applies to all newly installed parking places that fall within that category, irrespective of whether the parking place is separate or adjunct to the building. There are exemptions for residential buildings such as vacation cabins without road access or buildings that are not connected to the electricity grid. Municipalities have primary competence to decide where the parking place must be built.

3.3 Minimum number of recharging points set by national legislation for all non-residential buildings with more than 20 parking spaces, by 2025

Article 8(3) of the EPBD

Member States shall lay down requirements for the installation of a minimum number of recharging points for all non-residential buildings with more than twenty parking spaces, by 1 January 2025.

This sub-section provides an overview of the transposition of Article 8(3) of the EPBD (as well as equivalent measures in the non-EU countries covered). It indicates whether the adopted measures are 'a minima', or whether they go beyond EPBD requirements by applying an earlier deadline, requiring more than one recharging point, or by including requirements on ducting/pre-cabling.

Not transposed/reflected in national law as of May 2022

In Austria, the following Länder have not transposed this requirement: Burgenland, Kärnten, Wien, Oberösterreich and Steiermark. Steiermark requires installation of at least one charging point and ducting infrastructure in one parking space for every 25 parking spaces for new constructions and major renovations of certain buildings (including care homes, offices and administrative buildings, shops and event centres, restaurants and hotels, hospitals, schools, universities, commercial and industrial buildings), as well as in the construction of other publicly accessible parking areas with at least 10 parking spaces. However, this again does not correctly reflect the scope of Article 8(3) of the EPBD, as not all non-residential buildings with more than 20 parking spaces are covered, in particular existing non-residential buildings.

In Latvia, the legislation transposes 'a minima' the requirements of Article 8(3) of the EPBD, but only in relation to public buildings, i.e. buildings in which more than 50% of the total area of the building is a public premises or premises for the provision of a public function, or an engineering structure intended for public use (e.g. stages, stadiums).

In Luxembourg, buildings with more than 20 parking spaces must ensure that at least three in 20 have a charging point (up to a maximum of 25 charging points) and have an intelligent load management system. However, this only concerns new buildings or those undergoing major renovation.

In Lithuania and Norway, no relevant legislation was identified, nor any clear information on when relevant requirements would be adopted.

In the UK, no relevant requirements apply. For England, the initial proposal on amendments to the Buildings Regulations included an 'a minima' requirement reflecting Article 8(3) of the EPBD, but this was dropped due to concerns over costs for businesses. As a result, only new buildings and buildings undergoing work are subject to requirements under the amended Buildings Regulations. In Scotland, a consultation was carried out from 26 June to 28 November 2021 on proposed changes to the Scottish Building Regulations. Under the proposed amendments, by 1 January 2025, for buildings with more than 20 non-residential car parking spaces, one in every two non-residential parking spaces must have ducting installed and one in every 10 non-residential parking spaces must provide an EV charging point socket with minimum 7 kW output power rating. These amendments are still under negotiation.

A minima transposition

The following countries have followed an 'a minima' approach to transposition, following the letter of the EPBD and requiring at least one charging point for non-residential buildings with more than 20 parking spaces by 1 January 2025: Austria (Niederösterreic, Tirol, Voralberg), Cyprus, Czechia, Germany, Denmark, Finland, France, Croatia, Hungary, Ireland, Italy, Malta, the Netherlands, Slovakia and Sweden.

In Czechia, the transposing legislation has yet to come into effect and may be delayed or substantially amended by the new government. The implementing legislation laying down the conditions for installation of charging points has not been adopted yet.

Transposing measures that go beyond the EPBD requirements

The following countries apply an earlier deadline for the requirements: 1 January 2024 for Austria (Salzburg), and 1 January 2023 for Greece and Spain.

Some countries also have more stringent requirements concerning the number of charging points to be installed:

- In Belgium-Flanders and Portugal, the transposing legislation requires at least two normal or high-power charging points for an EV.
- In Romania, the legislation requires non-residential buildings with more than 20 parking spaces to install charging points in 10% of parking spaces, but in any case, in no less than two spaces;

- In Spain, all buildings other than private residential buildings that have a parking area with more than 20 parking spaces, either indoors or in an allocated outdoor space, as well as existing car parks not attached to buildings, with more than 20 parking spaces, shall have the following minimum EV charging infrastructure provisions:
    - In general, one charging station shall be installed for every 40 parking spaces or fraction thereof, up to 1,000 spaces, and one more charging station for every additional 100 spaces or fraction thereof;
    - In buildings owned by the State or its linked/dependent public bodies, one recharging station shall be installed for every 20 parking spaces or fraction thereof, up to 500 spaces, and one more recharging station for every additional 100 spaces or fraction thereof;
    - Specifically for the municipality of Madrid: by 2024, all car parks in buildings other than private residential buildings with more than 20 parking spaces will be required to have at least one EV charging point for every 40 parking spaces[173].
- In Poland, only one charging point in required, but the legislation also calls for installation of ducting infrastructure in 20% of parking spaces, whether inside or adjacent to the building;
- In Slovenia, ducting is required for 10% of parking spaces.

Bulgaria presents a particularly interesting case. As indicated above, the legislation sets shares of parking spaces for EVs for specific types of buildings (both residential and non-residential) in relation to the total number of parking spaces. Although the legislation is ambiguous, the most coherent interpretation appears to be that these shares also apply to existing buildings. Indeed, a footnote to Annex 5 specifies that the share of EV parking spaces is intended to be reached by 2030. This would suggest that existing buildings are included, as for new buildings or renovations, it would be logical to expect the infrastructure to be installed at the time of construction. The contrary interpretation would signify that additional work would have to be carried out subsequently in order to reach the specified percentage, which would presumably be significantly more expensive than installing the infrastructure from the outset. Consequently, Bulgaria does not align with the 2025 deadline in Article 8(3) of the EPBD yet appears to be the only Member State setting requirements for existing residential buildings.

3.4 Exemption for SMEs

Article 8(4) of the EPBD

Member States may decide not to lay down or apply the requirements referred to in paragraphs 2 and 3 to buildings owned and occupied by small and medium-sized enterprises as defined in Title I of the Annex to Commission Recommendation 2003/361/EC.

This sub-section provides an overview of the countries that provide derogations for SMEs in relation to e-mobility requirements in buildings.

In Austria, a derogation was adopted in the regions of Kärnten, Oberösterreich, Vorarlberg, but not in Burgenland, Niederösterreich, Salzburg, Steiermark, Tirol and Wien.

In Belgium, no derogation is in place in Flanders or Brussels-Capital. Wallonia has granted local government competence to adopt such an exemption, but it has not exercised this power.

[173] Ordinance 4/2021 of 30 March on Air Quality and Sustainability.

In Czechia, the derogation for SMEs may be set out in implementing legislation of the new Construction Law, but it has not been yet adopted.

Denmark adopted a law exempting buildings owned and used by a SME, with more than 20 parking spaces, from the obligation to establish at least one charging point by 1 January 2025.

In Germany, the exemption covers non-residential buildings owned by SMEs and mainly used by them. A similar exemption applies in Estonia, Croatia and Romania, where obligations do not apply to a non-residential building owned and used by an SME, with no additional conditions stipulated.

Ireland almost literally transposed the wording of Article 8(4) of the EPBD. This is also the case in France, whose national legislation exempts parking facilities in buildings owned and occupied by SMEs.

In Italy, the exemption seems larger in scope than Article 8(4) of EPBD, as it covers a broader set of situations than the requirements referred to in paragraphs 2 and 3, as well as Article 8(5).

In Malta, it is the Minister for Transport, Infrastructure and Capital Projects who decides not to lay down or apply the requirements to buildings owned and occupied by SMEs. To date, no derogations are in place for SMEs, although they have been requested by the SMEs Chamber.

In Poland, buildings owned by SMEs are not subject to requirements on the installation of recharging points and ducting for new non-residential buildings and non-residential buildings undergoing major renovation, or on the installation of at least one charging point and conduits for wires and electric cables by 1 January 2025 to enable the installation of charging points for at least one in five parking spaces for all non-residential buildings with more than 20 parking spaces. However, the Polish provisions transposing the EPBD refer to SMEs in the meaning of Polish Act rather than as defined in Title I of the Annex to Commission Recommendation 2003/361/EC. The reference provided for in Polish law should be considered incorrect, as the concept of SMEs defined in Polish law is not fully consistent with the EU definition.

In Portugal, the exemption from the obligation to install two charging points by 31 December 2024 encompasses buildings owned and occupied by SMEs, if duly certified in accordance with the law.

In Slovenia, requirements for non-residential buildings do not apply to buildings owned by small companies. The national provision also sets out an exception for non-residential buildings not connected to the public electricity grid.

In Finland, the exemption relates to the infrastructure rather than to ownership of the building, and covers the installation of recharging points or recharging capacity owned by micro-enterprises.

3.5 Exemptions for specific categories of buildings

Article 8(6) of the EPBD

Member States may decide not to apply paragraphs 2, 3 and 5 to specific categories of buildings where:

(a) with regard to paragraphs 2 and 5, building permit applications or equivalent applications have been submitted by 10 March 2021;

(b) the ducting infrastructure required would rely on micro isolated systems or the buildings are situated in the outermost regions within the meaning of Article 349 [Treaty on the Functioning of the European Union] TFEU, if this would lead to substantial problems for the operation of the local energy system and would endanger the stability of the local grid;

(c) the cost of the recharging and ducting installations exceeds 7% of the total cost of the major renovation of

Article 8(6) of the EPBD

the building;

(d) a public building is already covered by comparable requirements according to the transposition of Directive 2014/94/EU.

This sub-section discusses the extent to which Member States have applied any of the four types of exceptions provided for in Article 8(6) of the EPBD. It also presents the application of comparable legislative solutions by the non-EU countries covered by this study.

No exemptions adopted

Bulgaria, Ireland, Latvia, Luxembourg, Hungary, Slovenia and Iceland chose not to make use of the building exemptions under Article 8(6) of the EPBD. In Belgium and Malta, it is up to the national or local authorities to decide to exempt such buildings. Norway does not have such an exemption, and its guidance document generally mentions possible exemptions for certain types of buildings (i.e. holiday cabins without access to the road, isolated buildings).

In Belgium-Wallonia, the Walloon government has the power to adopt derogations ‘when the necessary connection infrastructure is based on isolated micro-grids’ and ‘when the cost of the charging and connection facilities represents more than 7% of the total cost of the major renovation of the building’. However, the exception linked to the total cost of renovation cannot be applied to parking for non-residential buildings with more than 20 spaces. To date, the Walloon government has not granted such derogations.

In Malta, the Minister for Transport, Infrastructure and Capital Projects has the power to decide whether or not exemptions will apply. They can only grant exemptions in cases of an application for a building permit, or its equivalent, submitted by 10 March 2021, where the cost of recharge facilities and ducting exceeds 7% of the total cost of the capital refurbishment of the building and where a public building is already subject to comparable requirements (points a, c, d of Article 8(6) EPBD).

Exemption for applications for building permits submitted before 10 March 2021 – Article 8(6)(a)

Estonia, Croatia, Italy, Cyprus, Poland, Romania, Slovakia, Finland and Sweden have made use of this transitional derogation. In Czechia, the derogation can be granted by virtue of implementing acts to be adopted with the new Construction Law, and in Malta, by virtue of a ministerial decision.

In Estonia, Italy, Cyprus and Slovakia, the exemption applies without limitation to a specific category of buildings.

Croatian legislation states that the exemption applies to residential and non-residential buildings, new building and those undergoing major renovation.

Poland introduced a more far-reaching exemption, extending the cut-off date from 10 March 2021 to 24 December 2021 so as to align exemption with the date of entry into force the amendment of the Polish Act on Electromobility. Polish legislation extends the exemption beyond building permits to encompass other administrative decisions obtained normally in the construction process, similar to a building permit, such as the decision to approve a plot or land development design.

Romanian legislation specifies that the exemption applies only to new or existent residential and non-residential buildings subject to major renovations, which have more than 10 parking spaces, for the construction of which the building permit applications was submitted by 10 March 2021.

Sweden's National Board of Housing, Building and Planning states that the new requirements apply only when a permit or notification was submitted after 10 March 2021. In **Finland,** the requirements apply to building projects for which an application for a building permit was submitted on or after 11 March 2021.

Stability of the grid – Article 8(6)(b)

Several Member States have made use of this exemption based on the risk of charging facilities causing network instability and issues with power system operability in isolated microgrids and in outermost areas. In Czechia, the exemption can be adopted through an implementing act introduced with the new Construction Law. In Belgium-Wallonia, the exemption can be adopted by the Walloon government when the necessary connection infrastructure is based on isolated micro-grids.

In France, the requirements are not applicable in areas without a connection to the continental metropolitan network, i.e., Corsica, overseas departments and regions (Guadeloupe, Reunion, Mayotte), territorial collectivities (Martinique, Guyana, Saint-Martin, Saint-Barthélemy), certain overseas collectivities (Saint-Pierre-et-Miquelon, Wallis and Futuna, in particular), the Ponant Islands (the islands of Sein, Molène, Ouessant and Chausey) and the Channel Islands of Chausey.

Romania limited the exemption to micro isolated systems as it does not have outermost regions withing the meaning of Article 349 of the TFEE. Italy also limited the scope of the exemption to micro isolated systems.

The exemption was introduced by Estonia and Croatia, with the latter making it applicable to residential and non-residential buildings, new buildings, and those undergoing major renovation.

Costs of the infrastructure exceeding 7% of total cost of the major renovation – Article 8(6)(c)

Several countries (AT, CZ, DE, DK, EE, EL, ES, FR, HR, IT, CY, NL, PL, PT, RO, SK, and UK) made use of this exemption.

In Belgium-Wallonia, the government can make use of this exemption when the cost of the charging and connection facilities represents more than 7% of the total cost of the major renovation of the building. The exception cannot be applied to non-residential buildings with more than 20 parking spaces. In Malta, the Minister may decide not to apply the requirements to specific categories of buildings where the cost of the recharging and ducting installations exceeds 7% of the total cost of its major renovation.

In Austria, Oberösterreich, Tirol and Vorarlberg adopted the exemption.

The exemption in Germany applies in case of a major renovation of an existing building, when the costs for the charging and line infrastructure exceed 7% of the total cost of the major renovation of the building.

Denmark applies the exemption in respect of major renovations of buildings that will subsequently have at least 10 parking spaces.

In Greece, the owner of an existing residential or non-residential building undergoing major renovation may be exempted from the obligations provided that the engineer responsible for the issuance of the building permit submits a Declaration of Honour to the Building Service of the Municipality, stating that the cost of the recharging and ducting installations exceeds 7% of the total cost of the major renovation of the building.

In Spain, the exception is applicable to buildings for use other than private residential use, with a parking area of not more than 20 parking spaces, and existing buildings for private residential use where, in both cases, the cost of compliance exceeds 7% of the cost of the extension, change of use or alteration that gives rise to the obligation to comply. The cost declared in the provisional tax statement for structures, installations and works is used to calculate the cost of the investment.

In Poland, the exemption applies to new residential and non-residential buildings. For buildings undergoing reconstruction or renovation, the exemption applies if the cost of work related to the technical partition of the building or technical systems is less than 25% of the building's value, not including the value of the land on which the building and parking are located, and when the installation costs of charging points and ducting infrastructure exceed 7% of the total cost of reconstruction or renovation.

In UK-England, the exemption applies to residential and non-residential buildings undergoing major renovation. In Scotland, the proposed amendments to the Scottish Building Regulations contain such an exemption.

Public buildings covered by comparable requirements – Article 8(6)(d)

Denmark, Estonia, Italy, Portugal and Romania have made use of this exemption for public buildings already covered by similar requirements under the transposition of Directive 2014/94/EU. It may still be adopted by Czechia by virtue of an implementing act to be adopted with the new Construction Law, while it may also be adopted in Malta through a decision of the Minister in charge of housing.

In Portugal, the exemption covers public buildings undergoing major renovation where the necessary charging infrastructure for EVs is already in place for this purpose.

The exemption in Romania covers public buildings that are subject to similar conditions in accordance with national law on the installation of the infrastructure of alternative fuels.

3.6 Additional legal requirements on e-mobility in buildings

This sub-section provides an overview of additional requirements on e-mobility not linked to the EPBD provisions. In particular, they identify whether the countries in question have adopted measures:

- On the installation of parking spaces and charging points for e-bikes;
- On smart/intelligent metering on smart charging;
- On the facilitation of V2G;
- On fire safety.

The following countries have not adopted these additional legal requirements on e-mobility: Cyprus, Germany (in federal legislation), Spain, Croatia, Hungary, Ireland, Latvia, Malta, the Netherlands (recommendations only), Portugal, Romania (recommendations only), Slovenia and Slovakia. Although no additional legal requirements are currently provided in Croatian national legislation, some future regarding smart/intelligent metering and facilitation of V2G might be implemented in by-laws in the near future. Similarly, Ireland has announced a National Smart Metering Plan, under which every home will be equipped with a smart meter by 2024. Denmark’s national legislation does not provide additional legal requirements but some guidance materials supporting an executive order on EV charging detail the specifications for ducting of cables to charging stations, in particular that the cable trays should be of such a size that it is possible to insert an electric cable afterwards.

The Netherlands and Romania have no specific additional requirements, but both provide recommendations. The Netherlands advises the use of a smart-meter system for use of charging points by third parties, as well as allowing the possibility to pay on the spot or to use authentication software for roaming. The charging points should be available for ‘smart charging’ and ‘load balancing’, and they should feature a sufficient level of data protection and cyber security. Romania specifies a number of optional elements if technically, economically and functionally feasible, including the infrastructure necessary for smart charging, accessibility of charging points for EVs for people with disabilities, parking infrastructure for e-bikes and means of transport for people with reduced mobility, smart metering, smart charging, and facilitation of the use of EVs batteries as source of energy.

Fire safety measures are in place or being considered in several countries, including Austria, Czechia, Belgium-Brussels, Denmark, Greece, France (not for non-covered buildings), Lithuania, Portugal and Iceland. Belgium-Brussels specifies that fire safety measures apply to all car parks of more than 10 parking spaces. Czechia has non-legally binding recommendations on fire safety of buildings related to e-mobility. The Danish authorities are currently looking into the fire risks associated with EVs in parking garages to assess if those risks exceed those for ICE vehicles. The results will inform an update of the fire safety regulations for buildings. Fire safety requirements are mentioned in Poland as part of the requirements that should be met when installing a charging point. In Lithuania, the general rules on fire prevention for electrical equipment installation also apply to EV charging infrastructure. Fire safety for EVs and charging infrastructure is included in Romanian law as an option if technically, economically and functionally feasible. Sweden allows, but does not recommend, charging EVs from an ordinary socket, with some recommendations made by the National Electric Safety Board, although local rules and guidelines can vary.

Belgium, Bulgaria, France, Lithuania and Sweden decided to establish additional requirements for bicycle parking spaces. Belgium requires any new car park to include bicycle spaces in ‘sufficient numbers’ for the activity of the site. For existing car parks, the renewal of the environmental permit must be accompanied by a quantitative and qualitative analysis of the adequacy of the bicycle spaces available. Bulgaria defines a minimum number of bicycle parking spaces for different types of buildings and the share of these spaces for bicycles parking for more than two hours and those parking for less than two hours. France made the construction of parking spaces for bicycles mandatory for certain categories of new buildings. Specific requirements for the installation of parking spaces for bicycles, such as the dimensions of parking slots or the distance from bicycle parking spaces to the entrance of the building, are specified in Lithuania’s legislation. It is also expected that similar requirements to those applied to EVs will shortly apply to e-bikes. A general obligation exists in Sweden to ensure that necessary parking places are present on a property, as well as requiring municipalities to plan for necessary parking infrastructure. The Land of Vorarlberg in Austria has set up specific rules concerning e-bikes, including the obligation to install parking spaces for bicycles, with appropriate ducting infrastructure for e-bikes in new constructions or major renovation of residential buildings with three or more apartments, and if these parking spaces are located inside the building or are physically adjacent to the building, are roofed, or enclosed by walls or other constructions.

In Estonia, building in urban areas generally requires a spatial plan, which must determine the possible location of any construction works for the building, which means that the location of charging infrastructure has to be foreseen and sufficient space reserved.

In Greece, local authorities have an obligation to develop plans for the recharging of EVs. These must include technical specifications for the installation of the ducting and cabling infrastructure necessary for recharging points, and fire safety measures that need to be taken for their installation and operation.

Finnish legislation lays down additional requirements for parking garages. The person undertaking the construction of a new parking garage intended for the use of parking for one or more residential buildings and that is subject to a building permit, must ensure that the parking garage is designed and equipped with recharging point readiness (ducting or cabling) so that recharging points can be installed in each parking spot. The same applies to large-scale renovations. One high-capacity recharging point or, alternatively, normal capacity points (depending on the size of the parking space) must also be installed.

In Luxembourg, for multi-family home dwellings, additional pre-wiring, or conduit for laying a cable for data transmission is to be provided between the termination point of a public communication network operator and the switchboard of the main distribution or the location of the collective intelligent load management system. A collective intelligent load management system must be installed for multi-family home dwellings. Additionally, pre-cabling or an additional conduit for laying a cable for data transmission must be provided between the termination point of a public communication network operator and the main distribution board or the location of the management system of the recharging power.

In Poland, national law provides the construction and technical installation solutions to be adopted when installing the recharging point, including requirements for the products used to install this point.

Measures promoting the interoperability of recharging stations and metering systems via a technical guide have been set up in France, and technical requirements were simplified. Housing co-ownership syndicates are obliged to add these matters to their meeting agenda before 1 January 2023.

Only the UK has introduced measures on smart charging functionalities where all charging points sold, offered or advertised in England, Wales and Scotland (other than public charging points, non-smart cables and rapid charging points) must have smart charging functionality (i.e. able to send and receive information via a communications network, able to respond to information received, capable of using the two previous functionalities to provide demand side response services, and having at least one user interface). In addition, charging points must be interoperable, capable of charging a vehicle if it loses communication network access, and have safeguards against the owner/end-user overriding the system in a way that could lead to safety risks. Charging points must measure the electricity consumed, adhere to the existing cyber security standard, and be configured to facilitate off-peak charging. In England in particular, charging points must be capable of providing a reasonable power output for each parking space for which they are intended to be used, must be run on a dedicated circuit, and must be compatible with all vehicles that may require access.

4 IDENTIFICATION OF BARRIERS AND OPPORTUNITIES FOR THE DEPLOYMENT OF RECHARGING INFRASTRUCTURE

Main findings

Regulatory barriers

- Rules requiring agreement of landlords/co-owners;
- Complex and/or lengthy authorisation and permitting procedures;
- Intervention of DSO;
- Separate building permits ;
- Lack of harmonised requirements across regions or municipalities;
- Multiple competent authorities;
- Lengthy administrative processes for obtaining power increases in older buildings;
- Lack of clarity (or absence) of legal requirements;
- Lack of technical specifications for recharging points;
- Ambiguous terms (e.g. ‘recharging point readiness’, ‘available for recharging’);
- Load-balancing;
- Financial aspects of recharging (e.g. need to clarify the business model for sharing a charging point);
- Lack of understanding of rights and obligations;
- Lack of adequate checks or enforcement;
- Scope of requirements (exclusion of existing buildings);
- Absence of rules addressing the needs of HDVs;
- Excessive fire safety requirements in underground parking of buildings;
- Extension of public distribution grids inside building parking spaces (bloc flexibility);
- Absence of requirements on smart charger installation;
- Prohibition on cables attached to chargers in buildings;
- Prohibition on installing Type-2 charging points in buildings with public access.

Technical/practical barriers

- Insufficient load centre capacity;
- Insufficient generation and distribution capacity;
- Shortages in qualified providers;
- Municipal technical services overwhelmed; shortage of technicians available;
- Competition for available parking spaces;

- Lack of data on housing stock and parking spaces.

Financial barriers

- High costs for existing buildings;
- High costs for developers in relation to perceived commercial advantage;
- Poor management of public grants for infrastructure;
- Recharging infrastructure mainly installed where business case already exists;
- Lack of business case for charging points sharing limits users;
- Lack of business case for installation of charging points in commercial sites, due to specific load demands.

Incentives

- Only a minority of countries offer no incentives to private recharging infrastructure;
- Incentives take the form of tax reductions or grants and subsidies;
- Significant variability in the amounts of these incentives, as well as eligibility (e.g. private persons only, housing associations, businesses).

Good practices

- Right to plug;
    - At own expense of person making request;
    - Notification instead of approval;
    - Refusal only possible in specified set of circumstances (e.g. co-owner association will install later, installation impossible);
- Facilitating co-owner decisions: mainly by enabling decisions by simple majority instead of absolute majority;
- Simplified planning and permission procedures: mainly exempting recharging infrastructure from planning permission;
- Additional policy practices: provision of guidance, information and template agreements to the relevant parties, training for real estate professionals;
- Pre-financing collective infrastructure.

The identification of barriers and opportunities is based on the country fiches for all EEA countries and the UK, as well as 10 in-depth country studies (DE, ES, FR, FI, LT NL, PT SE, and NO, UK) selected based on:

- Level of penetration of EVs;
- Experienced in developing legal and policy measures to promote e-mobility through building policy;
- Objectives foreseen for the development of EVs and recharging points in buildings and related incentive policies;
- Examples of cities and regions who are advanced in their approach to charging points in buildings and EV developments;
- Incentive measures in place;

- Geographical spread.

The in-depth country studies yielded insights into:

- Barriers to the installation and use of charging points in multi-residential and commercial buildings;
- Good regulatory and policy practices to develop EV charging points in buildings, at national, regional and city level;
- Areas of improvements;
- National stakeholders' preliminary recommendations on potential EU actions (EV users, building owners and managers, construction sector, DSOs, local authorities/municipalities, charging point installers).

Barriers and opportunities were also identified through discussions with stakeholders during the various consultation activities in this study:

- Focus Group on 5 May 2022;
- Working Group on Infrastructure, Platform for Electromobility on 12 May 2022;
- Workshop on 25 May 2022.

4.1 Main barriers to installation and use of recharging points in multi-family buildings and non-residential buildings

The barriers to deployment of e-mobility infrastructure in buildings can be broadly categorised as regulatory, technical or financial. This sub-section presents key examples for each of these categories for the countries covered by the study.

Regulatory barriers

One of the most frequently identified barriers relates to rules requiring the agreement of the owner or co-owners in multi-dwelling buildings to install recharging infrastructure. This issue applies to all countries that have yet to implement some form of a 'right to plug'.

However, even where the right to plug has been implemented in some form, issues may persist. For example, the right to plug in Spain (or proposed right in the Netherlands) only applies to owners, and tenants therefore still need to obtain authorisation from the landlord. It appears that individual installations can also be blocked if the cabling must go through a common area or a neighbour's parking space.

In Austria, the right to plug was implemented by changing the requirement from active to passive consent of co-owners, but some stakeholders feel that this may prove insufficient.

Issues related to complex and/or lengthy authorisation and permitting procedures were frequently mentioned as barriers. In several countries (DE, EL, RO, SE), the approval or intervention of the DSO is required to connect recharging infrastructure to the grid, which can result in the procedure being blocked or significantly delayed.

In some cases, separate building permits are required to install a recharging point (ES, HR) or the building licence must be updated where new metering equipment is required (EL).

In Czechia and the Netherlands, the relevant requirements are highly fragmented and spread across many different pieces of legislation, without any clear reference documents.

The lack of harmonised administrative requirements for authorising installation of charging points across different regions and municipalities was mentioned in several instances (AT, ES, SE). Rules prohibiting indoor recharging or subjecting it to additional ventilation requirements due to fire hazard concerns were indicated as examples (AT-Wien, SE).

A related point was raised in Belgium, where the multiplicity of competent authorities was considered a barrier.

In Portugal, the administrative processes for obtaining power increases in older buildings, as well as for the installation and certification of recharging equipment, were particularly lengthy and burdensome (in some cases taking more than three years).

A further category of regulatory barrier that emerged in many countries was legal requirements that are insufficiently clear or precise.

- A commonly mentioned issue (CY, FI, HU, IE, LU, SE) is the lack of technical specifications for recharging points. The Hungarian competent authority noted that in the absence of power supply specifications, compliance with requirements for minimum recharging point installation might be met with much lower capacity chargers (e.g. 3.7 kW instead of 22 kW). For Ireland, some chargers currently provided on the market are proprietary and could likely lead to compatibility issues should the co-owners' association decide to install recharging infrastructure later;
- In some countries (BG, FI), the ambiguity of terms such as 'charging point readiness' used in the legislation transposing Article 8(2) or 8(5) of the EPBD was identified as a barrier;
- The need for a harmonised approach to the financial aspects of recharging was also identified. In Sweden, stakeholders mentioned the need to clarify the business model for sharing a recharging point (who can sell electricity, and to whom), how those recharging at work without paying would be taxed for this benefit, and payment methods. In Portugal, it was highlighted that the lack of clarity on how the energy used for recharging in buildings is paid for could dissuade consumers from turning to EVs;
- The lack of requirements on load-balancing when installing recharging infrastructure was identified as a barrier in Sweden;
- The Bulgarian competent authority highlighted that the lack of clarity in the EPBD on the possibility to differentiate between sub-categories of non-residential buildings with regard to the type of property (non-residential buildings that are private property and those that are municipal or state property), and the dependence on the function/purpose of the building and pattern of occupancy, constitutes a barrier.

The lack of awareness or understanding of relevant regulations was mentioned as a barrier in several instances (ES, FR, SE). Even if requirements are in place to simplify deployment of e-mobility infrastructure, co-owners, property administrators, presidents of resident associations, or managers of commercial buildings are often unaware of their rights and obligations.

On a related note, issues of enforcement were highlighted as a barrier in Spain. These related to a lack of clear requirements for inspections to ensure compliance with relevant regulations, along with clear sanctions for non-compliance. The lack of proper verification of e-mobility requirements from authorities delivering building permits was also noted.

Denmark and Lithuania stated that where the building stock is partly owned by the municipality, the installation of recharging infrastructure can entail a lengthy administrative procedure. The municipality is required to put out a tender to select a private contractor for the recharging infrastructure installation, with an associated time-consuming process of drafting tender documents and evaluating the submissions.

In Finland, some stakeholders highlighted issues with the scope of the EPBD e-mobility requirements. There is currently 'a gap' in the housing stock of about 30 years between new buildings (built after 2020) and buildings that require large-scale renovations. The installation of recharging points or the 'recharging readiness' of buildings in this gap must be initiated solely by housing companies and/or residents. Even for buildings undergoing major renovations, many buildings would still be excluded if this provision were limited only to renovations 'including the car park or its electrical infrastructure'. The lack of requirements on existing residential buildings was also considered a barrier, with interviewees noting that it would likely be easier for residents to obtain approval from the housing association for installation of additional recharging points if one was already required to be installed. They called for the introduction of paced requirements for the installation of recharging points, for example, for those residential buildings that currently fall within this gap. They noted that it is difficult to categorise buildings falling into this gap, but proposed that the introduction of the requirements could be based on the year of construction or the energy efficiency class etc. so that completely 'useless' buildings (located in scarcely populated areas/for demolition, etc.) would be out of scope.

Some EU stakeholders consulted during a 25 May workshop as part of the study identified several regulatory barriers:

- Absence of rules that would address the needs of HDVs, notably providing tailored requirements for recharging points in logistics hubs and truck depots;
- Excessive fire safety requirements in underground parking of buildings, impeding the deployment of e-mobility;
- Extension of the public distribution grids inside building parking spaces (bloc flexibility). This can result in a doubling of meters for each consumer, with one for their home and one for their parking space, resulting in double the number of smart meters. The cost of this extension of the public grid is passed on to consumers through the distribution network tariff, which is unfair to those not living in multi-dwelling blocks. Such policies also prevent potential synergies between the dwelling and the vehicle, such as load-balancing, storage of solar panel electricity in cars or balancing the energy consumption of the apartment with that of the vehicle. The scenario described above materialised in France and was raised by various stakeholders;
- Absence of requirements on smart charger installation. The additional cost to install a smart meter is marginal, and smart recharging capabilities are essential to address load-balancing and capacity issues, as well as bringing cost benefits for consumers;
- Prohibition on attaching cables to chargers in buildings in France, requiring charging point manufacturers to develop a specific model and manage an additional reference in their product catalogues. Users must take their cable out of their car each time they are recharging;
- Absence of uniform procedures for decision-making process in respect of existing residential buildings;
- Prohibition on installing Type-2 charging points in buildings with public access, including in condominiums in Italy.

Technical/practical barriers

The most frequently identified issue was the lack of capacity of load centres in residential and commercial buildings[174] (FI, HR, HU, LT, PT, SE). This point was emphasised in feedback from stakeholders during consultation activities. For example, one Finnish stakeholder indicated the

[174] A load centre is used in residential and light commercial applications to distribute electricity supplied by the utility company throughout the home or building, feeding all the branch circuits.

importance of putting incentives and systems in place to ensure that home recharging occurs outside of peak hours. Recharging infrastructure at supermarkets or other commercial buildings should be fast-charging, given that customers are generally parked for short time periods and most customers visit at the same hours, which in turn requires more capacity from the electrical system and load centre. Some stakeholders believed that the insufficient number of transforming stations was one of the infrastructural deficiencies impeding the deployment of recharging infrastructures in buildings. In Finland, for example, it was mentioned that even if one housing association decides to install recharging infrastructure, this can be blocked by another housing association in an adjacent block if the neighbourhood transformer serving both of them cannot handle the additional load.

Shortages in qualified providers to install recharging infrastructure was identified as a barrier in several cases (BE, FI, LU). A link can be made here with another issue identified in several cases (FI, IE), namely that piecemeal individual installations of recharging infrastructure within a multi-dwelling building can lead to capacity and load management problems if the housing association later decides to install common infrastructure, due to differences in devices and capabilities. This is therefore a potential downside of right-to-plug measures. Ireland and the Netherlands noted that measuring individual consumption of electricity from a recharging point can create difficulties. It requires installation of a separate meter, which entails technical difficulties (space requirements, additional wiring), or connection to the existing individual meter, which is not always easy to identify or may be far away from the charging point. The alternative is to connect the recharging point to the supply of the common area, but this may cause load management issues and other residents will not want to pay for EV users' consumption.

In Spain, technical services in municipalities are often overwhelmed by requests, causing delays, and dedicated municipal technicians are often not available. This was confirmed by stakeholder feedback[175] emphasising that the expansion of the recharging network will place municipalities under increased strain regarding know-how and technical capacity. Another stakeholder added that municipal desk officers have a significant amount of power in this process, thus proper training and education on these new and technical issues could usefully address misconceptions and achieve smoother authorisations.

The purely practical issue of reluctance to reserve specific parking spaces for EVs where there is competition for a limited number of parking spaces was highlighted as a barrier in several countries (LT, HU, SI).

In Sweden, the lack of data available to public authorities on building stock and numbers of parking spaces was considered a barrier to effectively control and enforce e-mobility requirements. Some stakeholders indicated that the lack of information on capacities deployed at private locations was impacting planning for the deployment of public recharging points. They stressed that the lack of reports on electricity capacities of buildings also limited the installation of recharging points.

One stakeholder observed that too little attention was paid to the potential benefits obtained from a more symbiotic collaboration between charging points and buildings in the context of energy consumption management.

Financial barriers

The most frequently mentioned financial barrier was the high financial burden of installing e-mobility infrastructure in existing buildings, particularly since an overhaul of the electrical system is often required (BG, HR, HU, PT and UK). Similarly, the financial burden incurred for

[175] Working Group on Infrastructure, Workshop of the Platform for Electromobility on 12 May 2022.

installation of recharging infrastructure by co-owners who do not use it is likely to create resistance (FR).

In Hungary and the Netherlands, the costs for developers were mentioned, with one competent authority in Hungary adding that this can affect property prices, rents, and the amount of property built. On a related note, a stakeholder from France highlighted the hesitancy of commercial building owners to invest in recharging infrastructure, as they do not yet see the demand for it.

Another barrier identified in Spain and Sweden was inefficient management of public grants for installation of e-mobility infrastructure due to the multiplicity of entities involved.

In Denmark, the competent authority noted that because municipalities are prevented from commercially competing with EV recharging companies, recharging infrastructure is usually installed where the business case already exists. However, these rules were recently amended.

In the Netherlands, the lack of a clear business case for recharging point owners to share usage of the recharging point was identified as a barrier, as it limits the potential number of users.

In Finland, the additional capacity from the electrical system and load centre required for recharging infrastructure in supermarkets and other commercial buildings increases costs and has yet to be found commercially viable.

4.2 Good regulatory and/or policy practices for development of e-mobility infrastructure in buildings

Article 8(7) of the EPBD

Member States shall provide for measures in order to simplify the deployment of recharging points in new and existing residential and non-residential buildings and address possible regulatory barriers, including permitting and approval procedures, without prejudice to the property and tenancy law of the Member States

'Right to plug' and co-owner decisions

Some countries have adopted some degree of the right to plug concept, enabling tenants or owners to sidestep landlor/co-owner authorisation in order to obtain installation of EV recharging infrastructure. In some cases, the rules determining how co-owner associations can decide to install recharging infrastructure for the building have also been simplified.

In France, the owner of a building with secure access parking spaces for private use, or in the case of co-owned buildings, the condominium association represented by the managing agent, may not oppose without serious and legitimate grounds the fitting of parking spaces with installations dedicated to electric recharging for electric or hybrid rechargeable vehicles and allowing individualised metering of consumption, by a tenant or occupant acting in good faith and at their own expense. Serious and legitimate reasons include the pre-existence of such installations, the impossibility of carrying out the works, or the decision taken by the owner or syndicate of co-owners to carry out such installations to be effective within a reasonable period. A further specification is that the owner or managing agent of the co-owned building shall permit access to the technical premises of the building to the service provider chosen by the tenant or occupant acting in good faith. An agreement shall be concluded prior to the installation in a building of collective housing, between the owner and the provider of the installation, setting the conditions of access and operation to the common areas, for the installation, management, and maintenance of the installation. These rules are further specified in Articles R113-7 to R113-9 of the Code of Construction and Housing, detailing the notification obligation and procedure, and the procedure for owners to oppose the installation, as well as the procedure for the conclusion of the agreement between the owner and the provider of the installation. In addition, amendments were introduced to the legislation governing decisions of the assembly of co-owners, enabling decisions concerning the installation of recharging infrastructure to be taken by simple majority rather than absolute majority[176].

Similarly in Portugal, any condominium owner, tenant or legal occupant can install, at their own expense, an EV recharging point for exclusive or shared use in the building's carpark, provided they notify the co-owners at least 30 days prior to the installation. The co-owners or the landlord may only oppose this if a recharging point will be installed in the following 90 days that offers the same services and technology and meets the same needs for all potential users, or if such a recharging point already exists.

In Spain, the owner of an apartment in a multi-residential building is only required to notify the co-owners to install an EV recharging point for private use at their own expense. However, tenants wishing to install recharging infrastructure, even at their own expense, are still required to obtain authorisation from the landlord.

In Austria, a 2022 amendment to the Federal Act on Apartment Property (WEG) ensured that installations of a single phased 6A recharging point (3.7 kW) for EVs in a multiple party apartment house is a 'privileged change' in the sense of the WEG, i.e., it does not need the active consent of all co-owners. Consent is thus considered granted if there were no objections to the planned changes within two months of giving notice or there is not a majority in favour of the objection.

Poland established a specific procedure to enable residents of a multi-dwelling residential building to obtain installation of a recharging point. For an apartment community, a recharging point of <11 kW does not require prior authorisation for installation or operation. In other cases, the applicant is required to submit a request to the management board of the housing community or apartment cooperative or the person responsible for managing the property. The management board is then required to commission an expert on the installation within 30 days, which it must make available to the applicant, and then has another 30 days to consider the application. The application may only be refused in certain cases (an exhaustive list is given). It is also possible to forego an expert opinion where an electrical installation has been designed and constructed to supply recharging points. In this case, when installing the recharging point, the solutions for the electrical installation – particularly its technical parameters and security measures – are taken into account.

In Greece, in multi-property existing buildings, owners or legitimate users of a parking space can, at their own expense, install the necessary ducting and cabling infrastructure for a recharging point in their parking space, connected either to their own existing electricity supply, or through a new electricity supply issued in their name. The owner/legitimate user must submit a written notification to the manager of the building, who must then further inform all owners and tenants. After 30 days from the submission of the written notification, the owner may proceed to the installation, by using a certified electrician/installer. The general assembly of owners may only object to the installation for reasons of substantial obstruction to the use of the other parking spaces. This obstruction needs to be certified in a technical study by a mechanical engineer submitted to the competent Building Service of the Municipality. It must also be notified to the applicant for the recharging point.

[176] Loi du 10 juillet 1965 fixant le statut de la copropriété des immeubles bâtis, Article 24(5)(1).

In Romania, tenants and co-owners can install charging points at their own expense without the consent of the owner or the other co-owners, as long as this does not require modification of the building or the current electrical infrastructure.

In the Netherlands, proposed amendments to the Dutch Civil Code to introduce a right to plug were subjected to public consultation from June to September 2021[177]. This would enable owners to install recharging infrastructure at their own expense following simple notification to the other co-owners. No proposed changes were identified for tenants.

In Norway, the legislation has implemented a right to plug for owners of apartments, whether a 'property section' (self-owned apartment in a building)[178] or in a housing cooperative (joint ownership of the building, with exclusive use of the apartment)[179]. The request to install recharging equipment in a parking space with exclusive access or within the car park, if the owner has no private access to a parking space, may only be refused if there are factual grounds for doing so.

Other countries have taken measures to make it easier to obtain the approval of co-owners, but which fall short of a right to plug. In Finland, this is done via a guide providing basic information to residents of condominiums and other jointly owned properties[180]. This guide was updated in November 2018 to recommend that decisions concerning an increase in the capacity of the building's electrical system to accommodate charging points should be taken by simple majority. In addition, the Ministry of Justice is drafting a proposal to amend the current Housing Companies Act to facilitate the installation of recharging infrastructure in multi-residential buildings by allowing basic improvements and other reforms 'in line with sustainable development' (such as EV charging points) to be taken by a majority decision. A new subsection 3 is proposed to be added to Section 6:31 of the Act on Housing Companies (1599/2009), according to which the general meeting may also decide by ordinary majority on other reforms that (significantly) promote sustainable development, unless the shareholders' obligation to pay becomes unreasonably severe. Sustainability cannot be based on the views of the company's management or the majority shareholders, for example. The drafting of the law is envisaged to further clarify the aspects considered in the environmental assessment of the project. According to the draft memo, the presumption of sustainability of the measure could be based on other legislation (e.g. requirements on recharging points for electric cars), or sustainability could be demonstrated on a case-by-case basis. In the first scenario, a shareholder opposing majority decision-making could provide counterevidence that the measure does not promote sustainable development.

In Germany, some legislative changes were introduced, which still appear to favour the right to property over the right to plug. A tenant can request that their landlord allow them to make structural alterations to the rented property, including installation of EV recharging infrastructure, unless these changes cannot be reasonably expected of the landlord even after consideration of the tenant's interest. For condominium owners, alterations for the installation of charging infrastructure must be permitted by resolution of the other co-owners, or through agreement of all co-owners whose rights would be affected by the structural alteration, beyond what is unavoidable. Structural alterations that fundamentally alter the condominium, or which unfairly disadvantage one condominium owner over others, without their consent, may not be decided or agreed.

In Lithuania, a group of Members of Parliament submitted a proposal on 20 May 2022 to amend the Law on Electricity concerning the procedure for installing EV recharging stations in the car parks of apartment buildings[181]. The amendment proposes to enable co-owners in a multi-

[177] Overheid.nl | Consultatie Wetsvoorstel notificatieregeling oplaadpunten VvE's (internetconsultatie.nl)
[178] *Eierseksjonsloven* § 25a.
[179] *Borettslagsloven*, §5-11a.
[180] Kiinteistojen_latauspisteet_kuntoon_-_opas_paivitetty_05.11.2018.pdf (motiva.fi).
[181] Available in Lithuanian at: https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/a2035ff0744f11eaa38ed97835ec4df6/asr

apartment car park who have a parking space allocated for private use to bypass the agreement of the other co-owners to obtain installation of recharging infrastructure. Agreement is only required in respect of the routing of the cabling to the recharging point through the common structures.

Simplified planning and permitting procedures

The installation of charging points in buildings often requires authorisation or a permit from the relevant building authorities, as well as intervention of the DSO to connect the infrastructure to the grid. Some countries have taken measures to streamline this process.

In the UK, permitted development rights for off-street private EV charging points exist in England[182] since 2011 and Wales[183] since 2019. This means that planning permission is not required for installation of charging points, provided that certain requirements are met. Charging points can be installed, altered or replaced in areas of off-street parking if:

- They are not within 2m of the highway;
- 'Upstands' (bollards) do not exceed 2.3m in height (1.6m in Wales), or 0.2 cubic metres if wall-mounted;
- They are not within a site designated as a scheduled monument, or within the curtilage of a listed building;
- There is not more than one upstand for each parking space.

In Czechia, recharging stations equipped exclusively with a conventional recharging point (i.e. AC not exceeding 22 kW) can be placed without a decision or consent of the building authority[184]. Charging boxes located on the façade or inside of a building are considered a product, and no decision or consent is required from the construction authority to place them on a finished construction, unless this would require more invasive modifications[185]. Other types of recharging station can benefit from simplified land use and construction procedures intended for smaller constructions in general[186].

Denmark modified its legislation to enable housing associations to install and manage EV chargers for the benefit of housing association members. This was previously not allowed, as it was considered outside of the scope of permitted activities for housing associations.

Estonia took measures to ensure that the least onerous control method is applied. In practice, construction of recharging infrastructure requires notifying the authorities (electronically, in the Building Register) of the intention to build the recharging infrastructure (building notice) and after the completion of the works (use and occupancy notice), unless the works are part of larger project that requires building design documentation and a building permit. By default, the notices are just for information to the authorities. However, within 10 days, the authorities (local municipalities) may require approval from the competent authorities before building (or use). They may also set out further requirements for the construction work (architectural or engineering solution or appearance).

In Croatia, the installation of e-mobility infrastructure in buildings follows a simplified procedure where no building permit is required, as the works can be carried out based on the permit for the main structure[187].

[182] Town and Country Planning (General Permitted Development) (Amendment) (England) Order 2011.
[183] Town and Country Planning (General Permitted Development) (Amendment) (Wales) Order 2019.
[184] Act No 183/2006, s. 79 (2)(u).
[185] Act No 183/2006, s. 103(1)(d).
[186] Act No 183/2006, sec. 103(1).
[187] Ordinance on simple and other works and buildings (Official Gazette no. 112/2017, 34/2018, 36/2019, 98/2019, 31/2020).

Romania introduced changes to the legislation that empower the National Regulatory Authority (NRA)for Energy to define a simplified procedure for requesting connection of recharging infrastructure to the grid to the DSO[188]. However, the NRA has not yet adopted these rules. In addition, the competent authority is empowered to establish a simplified procedure for authorisation of recharging point installation within a within a maximum period of 45 days from submitting the request and the related documentation[189]. Again, no simplified procedure has yet been adopted.

In Slovakia, Article 8(7) of the EPBD has been transposed almost literally, via empowerment of the relevant Ministry to adopt regulations, but this remains an 'empty shell' as of May 2022 [190].

Greece is drafting a presidential decree to set out the rules and simplify the relevant procedures for the installation of recharging points in areas of special archeological and historical interest, in traditional settlements, in areas of special interest, or areas under a special cultural preservation status. These are expected to be adopted by the end of 2022.

Additional good practices identified by stakeholders

As part of the in-depth case studies, stakeholders were asked to provide examples of good regulatory or policy practices at national, regional, or local level. Incentive schemes were often mentioned and these are discussed in the next section of this report. Many of these measures concerned the provision of guidance, information and template agreements to the relevant parties. In France, several initiatives were highlighted at national level:

- Training real estate professionals via ADVENIR[191]. Training and information for condominium managers (*syndics de copropriété*) is organised, e.g. with the National Federation of Real Estate (*Fédération Nationale de l'Immobilier, FNAIM*) and the National Union of Real Estate Syndicates (*Union des Syndicats de l'immobilier, UNIS*)[192].

- France has published a guide on existing technical solutions in multi-residential condominiums (*Guide pour l'installation de bornes de recharge de véhicules électriques et hybrides rechargeables en copropriétés*), which includes information on the financial supports available (e.g. EUR 300 of tax deduction).

- The main stakeholders in the retail sector (large and medium supermarkets) have established a Charter of Commitment (Charte 'Objectif 100,000 bornes') to which a large number of companies have signed up. This brings them good publicity and facilitates access to the Minister on the energy transition. This has a spill-over effect on other stakeholders in the retail sector.

- Requirement for condominiums' general assemblies to put the matter on their agenda before 2023[193]. Limitations highlighted include the possibility to request a study on the projects, which, despite being well-intended, delays installations by 6-12 months, and the absence of follow-up beyond 2023 if the matter is discussed once but dismissed.

- Pre-financing of collective infrastructure.

[188] Law No 372/2005, Article 15(8).
[189] Law No 372/2005, Article 15(9).
[190] Act 555/2005 on energy efficiency in buildings, §9.
[191] Interview with the AVERE.
[192] Interview with the Ministry of the Ecological Transition.
[193] Interview with the AVERE.

In Spain, at national level, the main best practice concerns e-mobility incentives provided via MOVES plans (I, II, and III).[194] These were created to provide grants to encourage the acquisition of EVs, PHEVs and hydrogen fuel cell vehicles, and to implement efficient mobility measures at workplaces, the installation of recharging infrastructure, including for e-bike systems. The specifics of the grants are described in the following section.

Regionally, Cataluña and Madrid are seen as trailblazers on e-mobility issues. For example, the Community of Madrid has set up a good model in the legalisation of low voltage recharging installations, outsourcing the process to the Industrial Inspection and Control Entity (EICI), which simplifies the process by giving one body the power to legalise the installation rather than dealing with general deadlines set by the Ministry of Industry[195].

At local level, Madrid provides for more ambitious measures than the national transposition measures for Article 8 of the EPBD (see sections 3.1 to 3.3).

In the Netherlands, stakeholders identified the following national-level good practices:

- Guidance is provided on the website of the Netherlands Enterprise Agency (*Rijksdienst voor Ondernemend Nederland*) on the installation of recharging infrastructure at buildings[196];
- Several good practices concerned measures to simplify the installation of recharging infrastructure for owners' associations.
- Extension of the Energy Savings Loan by the National Energy Savings Fund to cover charging points and associated electrical infrastructure;
- Provision of subsidised expert advice to owners' associations on installation of the infrastructure, which can help to achieve a positive decision (the caveat expressed for the equivalent measure in France may also apply here);
- For the installation of a recharging point on Owners' Association (VvE) grounds, the report 'Charging solutions for electric cars within the VvE' was published in 2021 by order of the RVO[197], the municipalities of Amsterdam, the Hague, Rotterdam, Utrecht and the MRA-E[198]. This report indicates what needs to be considered when placing a recharging point on a VvE property;
- One website gathers together a lot of information on charging infrastructure and VvEs (https://vveladen.nl/).
- For the installation of a charging point, the ISSO Small Electric Transport (*ISSO Kleintje Elektrisch Vervoer*) offers all necessary practical knowledge. At regional level, the main best practice identified concerns the National Charging Infrastructure Agenda (NAL)[199], a long-term policy agenda with ambitions and actions to ensure that recharging can occur anywhere, anytime, and smartly in the Netherlands. The NAL is implemented at regional level and states that participating regions and municipalities must make efforts to include additional agreements with companies in existing and new agreements about the minimum amount of recharging infrastructure for business parks, without infringing

[194] https://www.idae.es/ayudas-y-financiacion/para-movilidad-y-vehiculos/plan-moves-ii
[195] Transport & Environment, Ecodes, Everis (2021) Estudio sobre el despliegue de la infraestructura de carga del vehículo eléctrico en España (p. 57)
[196] https://www.rvo.nl/onderwerpen/wetten-regels/laadinfrastructuur-elektrisch-vervoer
[197] Dutch Enterprise Agency: https://www.rvo.nl/
[198] MRA-Elektrisch (MRA-E) is a partnership of governments in the provinces of North Holland, Flevoland and Utrecht. MRA-E stimulates electric driving in this region in order to achieve policy goals regarding air quality and climate: https://www.mra-e.nl/mra-e/
[199] www.agendalaadinfrastructuur.nl

on property rights. This concerns existing buildings with up to 20 parking spaces, which fall outside the EPBD.

- At local level, the municipality of Rotterdam tried to gather an overview of the parking capacity in each building, which was considered a good practice in creating awareness.

In Sweden, the following national initiatives were considered good practice:

- Subsidy schemes are generous and successfully implemented;
- The National Electrification Strategy is very important and provides visibility on future requirements;
- The Electrification Commission has started a series of seminars on housing mobility for housing companies[200].
- A national competition on best practices in e-mobility in cities[201].

No particular good practices were identified at regional level, but at local level there were many examples of good public/private cooperation on e-mobility infrastructure:

- The Stockholm public housing company has adopted a form of ‘quick route’ for tenants to gain access to recharging. Although not quite a right to plug, a rapid check is performed to determine whether recharging can be offered, and a fixed monthly fee (independent of actual cost) is offered.
- In a brand-new initiative coordinated by the national Electrification Commission, five local public housing companies and one private housing company offer tenants a ‘softer’ version of the right to plug. They promise to work strategically and invest to offer recharging, do their utmost to quickly offer recharging opportunities to tenants, and always investigate opportunities when a tenant wants to charge[202].

In the UK, all charging points sold, offered or advertised in England, Wales and Scotland – other than public charge points, non-smart cables and rapid charge points – must have smart recharging functionality, be interoperable, capable of recharging a vehicle if it loses communication network access, and have safeguards against overriding of the system by the owner or end-user that could present safety risks. This was considered good practice for the development of smart chargers.

4.3 Incentives

Several countries have not implemented incentives for the installation of e-mobility infrastructure in buildings (BG, EE, LU, LV, MT and NO). Whether in the form of a tax deduction, subsidies or grants, the majority of the countries examined have introduced various measures to encourage the installation of such infrastructure.

Tax incentives

Several countries (e.g. BE, DK, EL, FR, HU, IT, NL, SE) relied on the introduction of tax deductions as a main incentive, or in combination with other measures, to encourage the installation of recharging infrastructure.

In Belgium, a system of tax incentives was established for the installation of recharging points. It enables private individuals who opt to purchase and install a recharging point (smart and

[200] https://www.regeringen.se/artiklar/2022/04/seminarieserie-om-laddinfrastruktur-for-bostadsbolag/
[201] https://www.2030sekretariatet.se/laddguldet-2021/
[202] https://www.regeringen.se/artiklar/2022/04/elektrifieringskommissionens-initiativ-klart-for-laddplats/

using only green electricity) at home between 1 September 2021 and 31 August 2024 (owners or tenants) to benefit from a tax reduction on their investment. The reduction will be progressively removed over time to promote rapid transition. The tax reduction on the investment is 45% between 1 September 2021 and 31 December 2022, falling to 30% in 2023 and 15% in 2024. The amount on which a tax reduction is granted and calculated is limited to EUR 1,500 per recharging point and per taxpayer. Companies that invest in a publicly accessible recharging station (freely accessible to third parties) between 1 September 2021 and 31 August 2024 will be able to avail of an increased cost deduction, which will subsequently be phased out: investments made between 1 September 2021 and 31 December 2022 have a deduction rate of 200%; investments made between 1 January 2023 and 31 August 2024 will have a deduction rate of 150%. Increased investment deductions will apply to companies that purchase a zero-carbon truck (as new) and install hydrogen refuelling infrastructure or an electric recharging station. The rate will be 35% in 2023, 29.5% in 2024, 24% in 2025, 18.5% in 2026 and 13.5% in 2027.

In Denmark, a tax reduction of approximately 1 DKK (EUR 0.13) per kWh applies to companies that provide EV recharging on a commercial basis.

Tax incentives are also in place in Greece for the purchase of EVs and recharging equipment for legal persons. These include depreciation of assets increased by 100% for purchasing a recharging station; expenditure discount increased by 50% (70% on the islands) when the recharging station is publicly accessible (when the electricity used for recharging is produced from renewable energy sources, documented through guarantees of origin, the expenditure discount increases to 70% and 90% for the islands); expenditure discount increased by 30% when the recharging station serves company needs; and recharging employees' EVs for job needs is considered a company expense.

In France, a tax credit of 75% is applied to private individuals, up to a maximum of EUR 300.

Hungary's legislation provides for the option of a tax base deduction for a recharging point. The cost of the recharging point – not exceeding the difference between the cost of the recharging point and the operating profit of the recharging point achieved during the three years following the date of completion of the investment, or that can be achieved based on the taxpayer's estimate – can be deducted from the tax base in the tax year in which the investment was made. The amount claimed for each recharging point may not exceed EUR 20 million EUR (in HUF equivalent).

With respect to commercial EV recharging incentives, Italy set a tax return of 40% of eligible expenditure for natural persons engaged in business, the arts and professions, companies, public and private bodies carrying on a commercial activity. Accordingly, the ceilings for recharging points with one source is up to EUR 2,500 and up to EUR 8,000 for recharging points with two sources.

In the Netherlands, EV recharging infrastructure incentives are mostly provided for private companies (although residents in most regions can request the installation of a public recharging point near their place of residence or work, free of charge, which would also be freely accessible to all residents). The commercial EV recharging incentives in the Netherlands include deductions of up to 36% on costs associated with purchasing and installing recharging stations, and a tax return of up to 75% of those same costs. Both the deductions and the tax return are available to companies and public entities.

In Sweden, individuals, households and housing cooperatives can apply for a tax deduction for green technology covering recharging infrastructure and foreseeing a deduction of 50% of the cost of labour and materials.

Grants and subsidies

Several Länder in Austria foresee subsidies for the installation of electronic recharging points in private buildings. Burgenland and Niederösterreich foresee such subsidies for electric recharging infrastructures, Oberösterreich and Steiermark for the installation of intelligent recharging points (in private buildings for Steiermark), Tirol for ducting infrastructure in private buildings and Vorarlberg for the installation of ducting infrastructure in existing buildings. A programme that expired at the end of 2021 had foreseen subsidies of EUR 600 for an intelligent recharging cable or EUR 600 for a home recharging point in a one-family or two-family house, or EUR 900 for an intelligent OCPP[203]-recharging point in a multiple apartment building, or EUR 1,800 for an intelligent OCPP recharging point in a multiple apartment building as part of a shared installation.

Belgium-Flanders introduced a project to roll out (semi-)public recharging infrastructure EVs at locations outside the public domain or within the public domain, where the private legal entity has a right *in rem* on part of the public domain. The maximum subsidy per project is EUR 300,000, allowing the reimbursement of investment in the placement and smart connection of recharging infrastructure at 20% of the cost, with a maximum of EUR 1,000 per charging point equivalent realised.

For family houses, Czechia introduced a subsidy to cover half of the cost of a wall box (up to CZK 30,000 (EUR 1,221)). Up to two wall boxes can be funded per family house. A subsidy may also be obtained for apartment buildings, to cover half of the cost of the recharging station (up to CZK 45,000 (EUR 1,831))), with the maximum number of recharging stations that can be supported corresponding to the number of housing units in the building. For entrepreneurs, the incentives for e-mobility are to be part of the National Recovery Plan (RRP), but specific calls have not been published yet.

At federal level in Germany, all German residents can apply for a EUR 900 grant to purchase and install a recharging station in their home. At state level, private individuals in Limburg an der Lahn can apply for a grant that covers up to EUR 300 for the purchase and installation of a recharging station at their home. In Hannover, private individuals in both single homes and condominiums can apply for a grant if the electricity powering the recharging station(s) is from a renewable source. Up to EUR 500 per recharging station can be claimed to cover purchase and installation costs (up to five stations per condominium). Munich has set up a subsidy covering up to 40% of the total net costs of a recharging station, which is open to private individuals, non-governmental organisations (NGOs) and apartment owners' associations. The amount that the subsidy covers equates to a maximum of EUR 3,000 per station with power of 22 kW or less, or EUR 10,000 for a fast-recharging station above 22 kW.

Cyprus recently announced a grant scheme providing financial incentives for the installation of a photovoltaic system in dwellings, for the purpose of recharging EVs or PHEVs from renewable energy sources[204]. It is expected to announce another grant scheme for the installation of recharging points in publicly accessible areas, businesses, and local authorities in the near future.

A pilot project in Denmark provides subsidies to install recharging points. Another subsidy scheme exists for housing associations to help to fund the installation of EV charges. The authority in charge of the scheme can provide subsidies of up to DKK 50 million (EUR 6.7 million).

The Greek government has announced a 10-year climate protection plan, which states that M1s and N1s will be subsidised at 15% of the purchase price, while the State will cover 25%

[203] Open Charge Point Protocol
[204] More information available here.

of the costs of electric taxis. In combination with tax breaks, M1s will become up to EUR 10,000 cheaper, while electric two-wheelers will also be subsidised. A financing programme co-finances the purchase of EVs for natural persons (non-professionals), taxis and public vehicles and professionals (legal persons). The purchase of an EV is subsidised to between 15% and 20% of the original price (for natural persons and legal persons/professionals), 25% for taxis and an ‘ecological bonus’ of 40% (up to maximum EUR 800) for e-bikes. The programme subsidises the purchase of smart home recharging points, with a standard amount of EUR 500. The continuation of subsidies for the purchase of EVs (for natural persons and for companies) and recharging equipment was expected to be launched in April 2022.

In Spain, a EUR 100 million programme aims to incentivise the acquisition of more sustainable vehicles and the development of recharging infrastructure. The amount paid depends on the EV range and whether the old car (registered before January 2013) is scrapped. Private individuals and businesses can receive grants of between 30-40% (up to a total of EUR 100,000) of the purchase and installation cost of public or private chargers. Another programme offers higher grant amounts for private EV owners and self-employed EV drivers (EUR 400, which can increase to EUR 800). It also aims to improve aid for recharging infrastructures for individuals, SMEs, and for fast and ultra-fast recharging infrastructures. These grants cover the procurement of plug-in electric infrastructure and fuel cells, and the installation of EV recharging infrastructure (with public or private access). For homeowners' associations, the pre-installation of electrical and communications services to provide intelligent recharging is eligible. The grants for the installation of recharging infrastructure for the self-employed, private individuals, and communities of owners cover up to 70% of the costs (80% in municipalities with fewer than 5,000 inhabitants), up to EUR 5,000 for natural persons, and EUR 800,000 for the rest.

In Finland, a grant of 35% of the actual costs can be awarded, up to a maximum of EUR 90,000. The grant will increase to 50% if at least half of the charging points to be installed have a recharging power of 11 kW or more. Grants can be applied for needs assessment, project planning, alterations to the power centre, changing the type of electricity connection, ducting and cabling, and the purchase of recharging equipment (only if owned by the beneficiary). The condition for the grant is that the housing association builds capacity for at least five recharging points. The cumulative aid per beneficiary cannot exceed EUR 200,000 over three years.

Croatia’s Environmental Protection and Energy Fund finances e-mobility, including electric recharging infrastructure, with HRK 10 million, through invitations to tender.

The Sustainable Energy Authority of Ireland provides a home charger grant of EUR 600 to assist individuals with the installation of charging points in off-street parking. The grant is available for BEVs and PHEVs and applies to both new and second hand EVs. The same authority concluded a consultation for a proposed two-tier EV Apartment Charger Grant Support Scheme. One tier is directed at owner management companies to assist them in installing the required electrical network and shared charges, while the second tier is intended to support individual residents of multi-unit developments.

An Italian programme provides subsidies for EVs and PHEVs, as well as EV infrastructure. Similarly, in Lithuania, a programme was set up in 2021 to disburse sustainable subsidies of EUR 161.6 million, of which EUR 5 million was given to residents buying an EV. The amount of compensation for one natural person to purchase a used EV is EUR 2,000 and EUR 4,000 for a new EV. An additional EUR 1,000 is awarded to an applicant who has scrapped their old vehicle. In 2022, after re-allocating funds from this programme, another EUR 1 million was used to compensate residents for the costs of purchasing an EV. In Poland, a call for proposals under a programme of support for EV recharging infrastructure and hydrogen refuelling infrastructure was announced in January 2022 and was available until 31 March 2022 or until the funding (PLN 870 million) was exhausted. The beneficiaries of this programme (including house companies and cooperatives) may obtain financial support in the form of non-refundable subsidies, including for projects to install recharging points.

In Italy, a refund of 110% exists on the costs of purchasing and installing recharging systems in apartment buildings in 2022 and 2023. The refund will reduce to 70% in 2024 and 65% in 2025. However, in order to claim the refund the EV recharging point installation must be part of wider energy efficiency renovations (thermal insulation of more than 25% of the building's dissipating surfaces or replacement of the heating system), which will increase the energy efficiency of the building by at least two classes. Expenditure ceilings are EUR 2,000 for single-family buildings or building units located within multi-family buildings that are functionally independent and have one or more independent access doors from the outside; EUR 1,500 for multi-family buildings or condominiums installing a maximum number of eight recharging points; and EUR 1,200 for multi-family buildings or condominiums installing more than eight recharging points. These ceilings may include the costs of increasing the power of the electricity meter, up to a maximum of 7 kW.

Portugal foresees the granting of 80% of the purchase value of the charger, including VAT, up to a maximum of EUR 800 per charger, one charger corresponding to one parking space, as well as 80% of the value of the electrical installation associated with the charger purchased (including VAT), up to a maximum of EUR 1,000 per parking space.

Under its RRP, Romania foresees 2,000 recharging points and 13,283 recharging stations. A financing programme is dedicated to SMEs and hotel/retail/catering (HORECA) operators, offering a non-refundable financing of up to EUR 100,000 if the SME/HORECA operator installs recharging stations of 22 kW for EVs and PHEVs. Applicants must install at least one of these recharging stations, with at least two recharging points for EVs and PHEVs.

Several schemes exist in Sweden, including one dedicated to recharging infrastructure for EVs, which is open to corporations, various organisations, and tenant-owned associations, but not to citizens or households. More general subsidy schemes for climate investment (e.g. to support recharging infrastructure) are also available and open to applications from individuals.

A Slovenian fund provides subsidies and soft loans for individuals, companies and public institutions engaged in environmentally friendly and/or energy efficient investments, including construction of energy-efficient buildings and renovation of existing buildings. To date, two schemes specifically allow for the subsidies and low-interest rates for financing of e-mobility infrastructure in non-residential and residential buildings. The first scheme provides subventions and low-interest loans for major renovation of multi-apartment buildings with eight or more apartments. Consent must be obtained from all owners to participate in the project. The financing criteria specifically provide that major renovations of houses with 10 or more apartments, for which a building permit is necessary, must include e-mobility ducting for all parking spaces. The non-repayable subvention can cover a maximum of 40% of the renovation costs and must not exceed EUR 450 per m^2 of net heated area of the building before the renovation. The loans can cover from 20% to 100% of the renovation cost and are granted with a variable interest rate of 1.3% + Euro Interbank Offered Rate (Euribor) three months. The second scheme provides loans to natural persons for major renovations of residential buildings and explicitly covers the costs of installing recharging points in existing buildings, irrespective of the number of available parking spaces. The loans are granted with a variable interest rate of 1.3% + Euribor three months. The loans can cover maximum 100% of the investment.

In Slovakia, the Ministry of Economy presented an action plan for the development of e-mobility, which contains several incentives for installing e-mobility infrastructure, such as long-term financial mechanisms to support the development of recharging infrastructure, the accelerated depreciation of electric cars, and recharging stations for EVs and indirect financial support for EVs.

Several grant opportunities are available in Iceland for the installation of recharging points in and around apartment blocks and non-residential buildings. The grants at national level are administered through an energy granting scheme run by the Energy Authority, while grants at local level are provided through several schemes run by municipalities. A repayment of 100% of the VAT cost in relation to the installation of recharging points in new and existing residential buildings is now possible.

Several grants exist in the UK, including the Electric Vehicle Homecharge Scheme, providing up to GBP 350 of the cost of purchasing and installing a home recharging point (ending at the end of March 2022). A recharging point can be claimed per eligible vehicle and for up to two eligible vehicles per household. An additional grant of up to GBP 250 is available to Scottish EV drivers via the Energy Savings Trust Scotland. A separate grant can be claimed by any business, charity or public authority and provides up to GBP 350 of the cost of purchasing and installing workplace recharging points, up to 40 sockets. The Scottish government also offers Scottish residents an additional grant of up to GBP 250 (or GBP 350 for those in the most remote areas of Scotland).

Other types of incentives

In Greece, M1s will be exempt from parking fees for two years, as part of the government's 10-year climate protection plan. Parking and entry exemptions are also applied to EVs in the major Lithuanian cities and in Norway.

Registration and information are available on the location of each recharging station of the French government's open data website.

4.4 Recommendations for potential future EU actions from interviewEES

This sub-section contains a list of recommendations on potential future EU actions suggested by the stakeholders interviewed at national level as part of the in-depth country studies and from stakeholders that participated in the focus group and workshop:

Changes to the EPBD:

- Better monitoring of the transposition and compliance of the e-mobility provisions of the EPBD, and set clear mandatory targets;
- The exemptions under Article 8(6) of the EPBD (the 7% rule) should be removed;
- Installation capacity should be considered further in the EPBD;
- Need to further characterise buildings in the EPBD. Building types should be better and more specifically categorised, with requirements that are less generic and more tailored to their specific consumption needs;
- A legal definition of 'smart recharging' should be developed, in line with the AFIR and REDIII proposal definitions;
- The need to further define 'physically adjacent parking';
- In urban areas, with rapid expansion of EVs, the requirement for one recharging spot for every 10 parking spots is insufficient;
- Investigate whether EPBD provisions should necessitate that recharging point operators make their infrastructure available to any other interested electricity supplier or EV aggregator, so that users can benefit from options (level playing field), or even

include their recharging consumption as part of their home/office supply contract and take it into account in any net-metering scheme;

- Each Member State should provide a minimum number of chargers, with Member States then granted more freedom to decide the percentage of parking spaces that requires the installation of chargers;
- Investigate whether parking areas not directly adjacent to buildings but relevant to their use (e.g. parking areas at a nearby plot, on the street, or at another building, which are allocated to employees/tenants working/living in the building) should include recharging points and whether such recharging points should be virtually connected with renewable energy source production from the building in question (e.g. through bilateral contracts, tariff exemptions);

Financial support:

- Increase of EU financial support to ensure the deployment of recharging points in buildings.
- A subsidy mechanism should be in place to realise connections to the electricity network of the network managers.
- Smart recharging solutions could be a criterion for subsidies for recharging infrastructure.
- Investigate whether the use of renewable energy source electricity produced by multi-unit buildings and used within their premises or at the vicinity (e.g., through peer-to-peer contracts) should be exempt from network tariffs, since the use of grid infrastructure is zero or negligible (e.g. a recent example in Portugal).

New objectives:

- More ambitious objectives to facilitate access to recharging. This could imply a strong regulation, even in terms of equipment (e.g., requiring the installation of recharging points). Any such solution should avoid pre-empting technological solutions. No solution should be imposed over another, considering that the set-up of the building may require a certain solution (e.g., exterior parking vs interior parking). New technologies are continuously emerging (e.g., robot recharging, multi-cable stations), which can respond to a wide range of diverging needs (e.g., very large multi-residential complexes, differing needs of each user, or lower needs for stations in social housing, and types of usage, such as charging at very high-speed stations in the public domain for 10 minutes rather than having an installation at home).
- Set objectives and guidelines on the calculation of needs, to assist national stakeholders with their use.

New EU requirements on cybersecurity and reliability of home management systems:

- Recharging infrastructure will be more integrated at home in a home management system. The EU should facilitate this development by drafting laws on the cybersecurity and reliability of home management systems and providing guidance on technical standards and protocols (all home appliances should ‘speak the same language’).

Additional requirements on power capacity:

- Consider the possibility for building owners to have a legal right to a minimum number of Amperes in their contract with the DSO.
- The power capacity of recharging stations should be taken into consideration.

Additional requirement on fire safety:

- Regulate fire safety to ensure that it does not conflict with the deployment of charging points, while ensuring adequate safety.

Deployment of recharging infrastructures based on use:

- Deploy recharging infrastructures based on their potential use rather than based on simple geographical distribution (e.g., it would be more efficient to locate the points near or within dwellings of professional drivers).

5 SELECTION AND EVALUATION OF POLICY OPTIONS

Several steps were undertaken to select a final shortlist of six policy options to accelerate recharging infrastructure deployment in buildings, facilitate the process to deploy recharging infrastructure, and ensure the future-proofing of recharging point installations:

- Identify policy end goals and key barriers;
- Develop a longlist of policy options;
- Engage with focus groups;
- Develop a draft policy shortlist;
- Conduct a stakeholder workshop (see section 1.3);
- Finalise shortlist and analyse policy options.

This led to this final shortlist of policy options:

1. In non-residential buildings, differentiate EPBD provisions by user profile of parking facilities (in Article 12(1) and Article 12(2) of the EPBD recast).
2. Implement reporting requirements on the number and nature of recharging infrastructure deployed in all buildings falling under the provisions of Article 12 of the EPBD recast.
3. Strengthen the provisions requiring pre-cabling and implement provisions requiring recharging point implementation in new residential buildings and residential buildings undergoing major renovations (Article 12(4) of the EPBD recast).
4. Eliminate or revise the exemptions under Article 8(6)c and Article 8(4) of the EPBD from 2018.
5. Include, as part of Article 12(8) of the EPBD recast, provisions requiring Member States to implement single national/local one-stop-shops (e.g. institutional entity, website) for process and legal guidance and assistance to in-building charging infrastructure deployment for owners, tenants and users of parking spaces in buildings.
6. Adopt Article 12(6) of the EPBD recast (Member States shall ensure that […] recharging points […] are capable of smart charging, and where appropriate, bi-directional charging).

5.1 End goals of policy options and barriers to address

With the overall objective of promoting e-mobility through buildings policy, three specific policy goals were identified:

- *Accelerate recharging infrastructure deployment in buildings;*
- *Facilitate the process of deploying recharging infrastructure in buildings;*
- *Ensure future-proof recharging installations.*

While buildings policy is crucial for the deployment of passenger car e-mobility, specific consideration was also given to its role in facilitating the deployment of electric commercial medium vehicles and HDVs, as the availability and adequacy of charging infrastructure is a major barrier to adoption of these types of vehicles[205].

The barriers (identified in section 4.1) that slow down achievement of the policy goals are mapped against the goals below:

Barriers related to *accelerating recharging infrastructure deployment in buildings*:

- Scope of the EPBD e-mobility requirements: not all buildings or off-street parking lots are within scope;
- Shortage in qualified providers;
- Technical services in municipalities are often overwhelmed;
- Reluctance to reserve specific parking spaces for EVs where there is competition for a limited number of parking spaces;
- Lack of data on building stock and number of parking spaces (for enforcement purposes);
- Financial burden of installing e-mobility infrastructure in existing buildings;
- Costs for developers of new buildings;
- Costs for owners of existing commercial buildings (charging infrastructure is not considered to be commercially viable by those owners).

Barriers related to *facilitating the process to deploy recharging infrastructure in buildings*:

- Lack of agreement from owner/co-owners in multi-dwelling buildings to install recharging infrastructure;
- Complex and/or lengthy authorisation and permitting procedures;
- Insufficiently clear or precise legal requirements;
- Absence of a uniform procedure for the decision-making process in existing residential buildings;
- Lack of awareness or understanding of relevant regulations (by co-owners, property administrators, presidents of residents' associations, managers of commercial buildings, etc.);
- Difficulties in determining how costs should be shared between co-owners;
- Inefficient management of public grants for charging infrastructure (too many entities involved);
- Concerns about increased load on the electricity grid, limitations in grid connection, and lack of in-building charging management of loads.

Barriers related to *ensuring future-proof installations*:

- Lack of capacity of load centres in residential and commercial buildings;
- Lack of data on electricity capacities of buildings;
- Absence of legal and regulatory requirements on smart charger installation.

[205] https://www.sciencedirect.com/science/article/pii/S1361920922001456

Barriers related to *accelerating recharging infrastructure deployment in buildings for commercial EV fleets:*

- Absence of rules to address the needs of HDVs.

Financial barriers were identified and discussed with the Commission (see section 4.1). However, it was, agreed with DG ENER that policy options targeting financial incentives and financial mechanisms would not be analysed here, as these aspects rely on horizontal instruments that are outside the scope of the EPBD. The topic would therefore benefit from a dedicated study.

5.2 Longlist of policy options

The definition of the longlist of policy options was an intermediate step leading to the final selection and evaluation of policy options (shortlist). It considered: early findings from Tasks 1 to 3 (in particular the barriers identified (see section 5.1) and country-level or sub-national best practice policies identified); the EPBD 2021 impact assessment (Annex I) findings; the EPBD recast released in 2021; and published stakeholder reactions to the EPBD and the EPBD recast[206]. The longlist of policy options is listed in Table 16 and the six policy options retained for the shortlist are discussed in section 5.4.

[206] For example, AVERE, *Reaction paper to the revised Energy Performance of Buildings Directive*, n.d.; ChargeUpEurope's, *Input to the Consultation on the Revision of the Energy Performance of Buildings Directive – additional comments*, 2021.

Table 16: Longlist of policy options

Policy end goal	Barrier(s) to address	Policy option	In shortlist	Comments and rationale for shortlisting
• Accelerate	- Scope of EPBD e-mobility requirements: not all buildings or off-street parking lots are within scope - Insufficiently clear or precise legal requirements	**Expand and refine the definition of 'major renovation' and provide a precise definition of 'pre-cabling'**		- Barriers associated with the policy option are relevant, and more precise/modified definitions have the potential to significantly expand the scope of EPBD requirements, change the number of buildings falling under the EPBD requirements, and accelerate their EV readiness - A change in definition of 'major renovation' would affect all EPBD articles and would need to be addressed holistically - Recommendation to better define some terms of the EPBD was made by interviewees (section 4.4) - A general discussion about definitions in Article 12 of the EPBD recast is included at the end of section 5.4, providing additional considerations worth exploring, beyond the six shortlisted policy options
• Accelerate, Facilitate	- Installation costs in existing buildings - Cost for developers of new buildings - Costs for commercial buildings (charging infrastructure not being commercially viable) - Cost-sharing between co-owners, cost splitting/accounting - Inefficient management of public grants for charging infrastructure (too many entities involved)	**Strengthen financial incentives at national and local level** **Design innovative financing mechanisms to further support charging infrastructure deployment (e.g. RRP funding, Emissions Trading Scheme (ETS) revenues from the buildings and/or transport sector (once those sectors fall under the ETS), using energy efficiency obligations under the Energy Efficiency Directive)**		- See discussion on policy options relative to financial barriers in section 5.1 - As a result, these policy options were not further researched or not discussed with stakeholders in the focus groups and the workshop

Policy end goal	Barrier(s) to address	Policy option	In shortlist	Comments and rationale for shortlisting
• Accelerate, Facilitate	- Reluctance to reserve specific parking spaces for EVs where there is competition for a limited number of parking spaces - Installation costs in existing buildings - Cost for developers of new buildings - Costs for commercial buildings (recharging infrastructure not commercially viable) - Cost-sharing between co-owners, cost splitting/accounting	**Remove the 7% cost exemption[207] and possibly implement innovative and effective compliance alternatives to charging infrastructure deployment targets in buildings**	X	- Given the already slow rate of major renovations in the total building stock (see section 2.3.3), exemptions risk further delaying effective pre-cabling and recharging point deployment and thus the effectiveness of the EPBD in promoting e-mobility - Removal of the 7% rule recommended by interviewees (section 4.4) - Possible implementation of alternative compliance mechanisms in cases where the costs, complexity or risks are considered too high may offer flexibility in complying with the EPBD requirements while ensuring a contribution from all buildings towards the common goal of recharging infrastructure deployment, and address some of the barriers for local stakeholders (see left-hand column) - Investigating whether parking areas not directly adjacent to buildings but relevant to their use (e.g. parking areas at a nearby plot, on the street, or at another building) could include recharging infrastructure which would be associated with a specific building was recommended by interviewees (section 4.4)
• Accelerate	(Policy options that aim to increase the level of ambition of the 2018 EPBD and/or of the EPBD recast do not directly relate to a barrier to the installation and use of recharging points in buildings (see section 4.1))	**In addition to Articles 12(1) and 12(2) of the EPBD recast, in new and/or existing non-residential buildings, pre-cable every parking space dedicated to employees and deploy charging infrastructure in line with employees' daily needs**	X	- Aims to increase the level of ambition of the EPBD recast while ensuring sufficient anticipation and provision of recharging infrastructure for all employees, regardless of the non-residential building type (office or non-office type of building) - A further differentiation of EPBD provisions by building type was recommended by interviewees (section 4.4)[208] - Included in the shortlist under: 'In non-residential buildings,

[207] 2018 EPBD: Member States may decide not to apply paragraphs 2, 3 and 5 to specific categories of buildings where: […] the cost of the recharging and ducting installations exceeds 7% of the total cost of the major renovation of the building.

[208] Suggests a further differentiation by user type of parking facilities, which is slightly different than a differentiation by building type but can achieve similar improvements in accurately targeting the deployment of recharging infrastructure.

Policy end goal	Barrier(s) to address	Policy option	In shortlist	Comments and rationale for shortlisting
				differentiate provisions by user profile of parking facilities (in Article 12(1) and Article 12(2) of the EPBD recast)
• Accelerate	(Policy options that aim to increase the level of ambition of the 2018 EPBD and/or of the EPBD recast do not directly relate to an expressed barrier to the installation and use of recharging points in buildings (see section 4.1))	**Implement pre-cabling and recharging point installation targets in existing residential buildings by a certain year**		- Aims to increase the level of ambition of the 2018 EPBD and the EPBD recast by including provisions for all residential buildings in the same manner as for non-residential buildings (Article 12(2)) - Given barriers due to the complexity of the decision-making and cost-sharing process for pre-cabling and recharging infrastructure deployment in existing residential buildings not undergoing major renovation (see section 5.1), mandating such deployment instead of leaving it to the discretion of building users (within a timeline that fits their individual needs) seems too complex and unrealistic. Similar views were expressed by stakeholders in the focus groups and workshop
• Accelerate, Facilitate	(Policy options that aim to increase the level of ambition for recharging infrastructure deployment of the 2018 EPBD and/or of the EPBD recast do not directly relate to an expressed barrier to the installation and use of recharging points in buildings (see section 4.1))	**Take into account the pre-cabling and deployment of recharging infrastructure in the EPBD's energy use reduction targets, e.g. via relaxation of the energy target for a level of recharging readiness going beyond EPBD requirements**		- Explicitly integrates recharging readiness within the energy performance considerations of buildings - Increases the flexibility for building developers and managers in meeting EPBD targets, while potentially accelerating the recharging infrastructure deployment in buildings - The adoption of such a policy option would impact the EPBD beyond Article 12 ('Infrastructure for sustainable mobility') and possibly be detrimental to the effective improvements in energy performance of buildings driven by the EPBD - Not deemed a high priority by stakeholders in the focus groups and workshop
• Facilitate		**Frame pre-cabling and recharging point installation targets based on EV deployment targets rather than parking space targets**		- When targets are based on the number of parking spaces in buildings, the effective recharging infrastructure deployment is subject to parking space per inhabitant requirements in building codes and therefore to the number of parking spaces deployed, rather than effective recharging infrastructure needs. This links recharging infrastructure to a car-centric vision, as more

Policy end goal	Barrier(s) to address	Policy option	In shortlist	Comments and rationale for shortlisting
				recharging infrastructure will be deployed when more parking spaces are made available - Offers a potentially better tailored and cost-effective way to deploy charging infrastructure, in line with EV deployment - Targets based on the number of parking spaces in buildings may better ensure sufficient recharging infrastructure supply to support EV adoption and better predictability than targets based on EV deployment, which may be less predictable and fast-evolving - A change in the formulation of targets in Article 12 of the EPBD would require a major reformulation and evaluation of the effects on all provisions - A more detailed discussion about the formulation of targets in the Article 12 of the EPBD recast is included at the end of section 5.4, providing additional considerations beyond the six shortlisted policy options
• Accelerate	(Policy options that aim to increase the level of ambition of the 2018 EPBD and/or of the EPBD recast do not directly relate to an expressed barrier to the installation and use of recharging points in buildings (see section 4.1))	**Increase the numerical targets of the EPBD recast and provide intermediate milestones**		- Implementation of longer-term targets (e.g. implementing 2030+ targets in existing buildings not undergoing major renovation or adding post-2027 targets in non-residential buildings) may provide additional visibility to stakeholders, support them in anticipating recharging infrastructure deployment efforts, and provide additional certainty for consumers in their EV adoption projects - The EPBD recast already suggests significantly more ambitious targets and provisions than the 2018 EPBD (see section 2.3.2) - Chapter 2 (section 2.3.1) suggests that a recharging infrastructure deployment in line with the EPBD recast targets would lead to pre-cabling and recharging point availability in most building types falling under Article 12 of the EPBD recast, sufficient to meet and anticipate near-term (2030) EV deployment, but generally insufficient in a longer timeframe

Policy end goal	Barrier(s) to address	Policy option	In shortlist	Comments and rationale for shortlisting
				(2050) - Any increased targets need to be balanced against costs and complexity barriers raised by stakeholders (see section 4.1)
• Facilitate	- Lack of data on building stock and numbers of parking spaces (control and enforcement)	**Implement reporting requirements on the number and nature of charging infrastructure (pre-cabling and recharging points installed) deployed in buildings**	X	- This would allow systematic tracking of the application and effectiveness of the EPBD - This would allow the collection of reliable data for charging infrastructure deployment in buildings - Better monitoring of the transposition of the e-mobility provisions of the EPBD and their compliance was recommended by interviewees (section 4.4)
• Accelerate, Facilitate	- Agreement of owner or of co-owners in multi-dwelling buildings - Complex and/or lengthy authorisation and permitting procedures - Insufficiently clear or precise legal requirements - Absence of a uniform procedure for the decision-making process in existing residential buildings - Lack of awareness or understanding of relevant regulations - Cost-sharing between co-owners, cost splitting/accounting	**Include, as part of Article 12(8) of the EPBD recast, provisions requiring Member States to implement single national/local one-stop-shops (e.g. institutional entity, website) for process and legal guidance and assistance to in-building charging infrastructure deployment for owners, tenants and users of parking spaces in buildings**	X	- Given the repeated nature of the barriers mentioned by stakeholders around the complexity of recharging infrastructure deployment in buildings in practice, this policy option was selected for the shortlist and is further discussed in section 5.4
		Request Member States to prepare clear and accessible national guidelines for roles, responsibilities and costs-sharing for pre-cabling and recharging point installation (including grid connection and metering) between	X	- An example of such guidelines (for co-owners of apartment buildings) exists in France (section 4.2.3)[209] - Further investigated and discussed in the shortlist of policy options within: ▪ policy option 5, on implementing one-stop shops for providing clarity on existing processes and rules to consumers

[209] https://www.avere-france.org/wp-content/uploads/site/documents/1618487546204508706eef474d2fa0a5065e75f36-AVERE_GUIDE_INTERACTIF_15042021.pdf

Policy end goal	Barrier(s) to address	Policy option	In shortlist	Comments and rationale for shortlisting
	- Inefficient management of public grants for charging infrastructure (too many entities involved)	**stakeholders, by building type**		▪ policy option 3, on strengthening provisions for residential buildings, where shortcomings and further improvements of the right-to-plug concept are discussed
		Further smoothen the decision-making process to implement recharging facilities in existing buildings, in particular between building managers and distribution grid companies, and between building owners or managers and apartment/offices tenants or owners		- Tackling recharging infrastructure deployment in existing buildings is complex, in particular in residential buildings with multiple owners and tenants, for timing of recharging infrastructure deployment (recharging infrastructure may not be needed for all buildings' occupants at the same time) and cost-sharing reasons - Discussion and suggestions for increased clarity in the decision-making process for recharging infrastructure deployment in existing residential buildings is provided in section 5.4, under the shortlist policy option 'Strengthen the provisions requiring pre-cabling and charging point implementation in new residential buildings and residential buildings undergoing major renovations (Article 12(4) of the EPBD recast)' - Aspects of this policy option are not directly in the scope of the EPBD
• Facilitate		**Provide a maximum timeframe to accede to residents' demands to install a recharging point**		- Barriers associated with the policy option are relevant and the shortlist policy option 'Strengthen the provisions requiring pre-cabling and recharging point implementation in new residential buildings and residential buildings undergoing major renovations (Article 12(4) of the EPBD recast)' aims to overcome the remaining shortcomings of the right-to-plug concept (see section 5.4)
• Ensure future-proof installations		**Require all installations (from pre-cabling to recharging point installation) to be V2G (i.e. bi-directional)-capable**		- Future-proof installations may somewhat contradict accelerated charging infrastructure deployment objectives in the short-term (due to cost and complexity implications) but aim to allow the recharging infrastructure to run most cost-effectively and CO_2-effectively in the future. User interests and system-wide interests may somewhat diverge in the short-term

Policy end goal	Barrier(s) to address	Policy option	In shortlist	Comments and rationale for shortlisting
				but converge in the longer-term - A regulatory obligation to implement a technology that is not fully mature, and would increase deployment costs for recharging infrastructure is risky in the near-term, while a cost-effective deployment of V2G capabilities may be market-driven - The case-by-case requirement of Article 12(6) of the EPBD recast (Member States shall ensure that […] recharging points […] are capable of smart charging, and where appropriate, bi-directional charging) may be better adapted to support V2G deployment
• Ensure future-proof installations		**Explicitly request that the recharging infrastructure installed should meet European norms and standards**		- Should be automatic within European legislation, thus this policy option is excluded from the shortlist
• Ensure future-proof installations	- Concerns for increased load on grid and limitations in grid connection and need for in-building charging management to spread loads - Lack of capacity of load centres in residential and commercial buildings - Lack of reports on electricity capacities of buildings - Absence of requirements on smart charger installation	**Request that the building's grid connection is dimensioned so that each future charging point can operate simultaneously at a pre-defined, minimum capacity**		- The EPBD recast mentions that 'pre-cabling is dimensioned so as to enable the simultaneous use of the expected number of recharging points', without specifying if the recharging capacity in practice during simultaneous use should meet a certain minimum. For example, the City of Oslo requires that 'the grid capacity in new buildings must be designed to charge at 3.6 kW all of the vehicles in the building without any need for smart charging to prevent local power shortages'[210]. Such a policy option could ensure that the recharging infrastructure is of sufficient quality to satisfactorily fulfil users' needs - Defining such minimum power may depend by Member State and on local circumstance, and implementing such a requirement in the EPBD would require further research - Mandating a minimum recharging capacity at all times may be counter-productive for smart load management (smart

[210] https://www.nordicenergy.org/wordpress/wp-content/uploads/2018/05/NordicEVOutlook2018.pdf

Policy end goal	Barrier(s) to address	Policy option	In shortlist	Comments and rationale for shortlisting
				recharging) at building level or system level and may lead to less flexible and more costly infrastructure - The issue of the 'simultaneous use […] of recharging points' is discussed at the end of section 5.4, providing additional considerations beyond the six shortlisted policy options
• Ensure future-proof installations		**Request the implementation in residential buildings and office buildings with more than a certain number of parking spaces, a smart charging system internal to the building that ensures the recharging needs of all residents while mitigating capacity demand and grid connection constraints**		- This would address the associated barriers, but would also make the recharging infrastructure deployment process in buildings more complex and possibly increase costs - The need for such in-building smart charging system may be better investigated and decided on a case-by-case basis, balancing grid connection costs (including possible upgrades needed) and the cost of implementing a smart recharging system
• Accelerate (commercial EV fleets)	- Absence of rules to address needs of HDVs	**Expand the EPBD scope to commercial medium and HDV depots and implement specific and adapted provisions**	X	- This is included in the shortlist, under the policy option 'In non-residential buildings, differentiate provisions by user-profile of parking facilities (in Article 12(1) and Article 12(2) of the EPBD recast)'

5.3 Focus groups and workshop

Two focus groups were carried out under Tasks 2 and 3 to obtain stakeholders' feedback. One session during each focus group was dedicated to vetting the longlist of policy options. This feedback was later used in a two-hour online workshop with the stakeholders, including the Commission (DG ENER and Directorate-General for Mobility and Transport (DG MOVE)) (see section 1.3).

The workshop objective was to develop a shortlist of policy options that address the key barriers to installing EV recharging points covered under the EPBD.

5.4 Final policy options

The final six policy options for updating the EPBD to support e-mobility are listed below and were developed based on several criteria:

- Options respond to one or more of the end goals and barriers identified (see sections 5.1 and 5.2, in particular the discussion developed for each policy option of the longlist in Table 16);
- Policy options are suitable to be adopted (although they may be refined and/or adapted) in an EU directive context – more precisely, in the framework of this study, within the EV charging infrastructure provisions of the EPBD (i.e., policies more suitable for adoption at the national or local level, through non-binding guidelines or through another form of legal text, were not selected);
- European Commission and stakeholder feedback and priorities gathered over the course of the project were considered (see discussion for each policy option of the longlist in Table 16) (see section 1.3).

In addition to the six policy options, some additional considerations are included at the end of this section. These stem from the longlist but are not policy options *per se*.

Goal: Accelerating recharging infrastructure deployment in all buildings (including for commercial medium and HDVs)

- *In non-residential buildings, differentiate EPBD provisions by user profile of parking facilities (in Article 12(1) and Article 12(2) of the EPBD recast)*

Some non-residential facility actors question the relevance of mandating recharging infrastructure deployment on their premises that may not be economically viable (see section 4; summaries in sections 5.1 and 5.2). In parallel, the EPBD does not explicitly ensure that all employees (including those not working in an office) can be guaranteed recharging facilities at their work premises within a short timeframe – which is essential to support vehicle owners' decision-making in adopting an EV – nor does it ensure that the EPBD effectively supports the accelerated adoption of commercial medium and HDVs.

AVERE notes that recharging infrastructure for medium and HDVs largely falls out of the scope of the EPBD and suggests that 'the revision proposal should therefore be amended to cover new or renovated private truck depots […] as well as logistic hubs and distribution centres […], requiring them to be ready for battery electric truck charging'[211].

[211] https://www.avere.org/wp-content/uploads/AVERE-Reaction-paper-revised-Energy-Performance-of-Buildings-Directive-EPBD.pdf

The policy option therefore introduces a differentiation between the uses of the parking facilities in non-residential buildings[212] and suggests a possibility for further developing EPBD provisions so as to address the barriers identified and explicitly target priority areas for recharging infrastructure deployment.

Employee vs. non-employee needs

Recharging needs for users of non-residential buildings' parking facilities are likely to differ significantly by user type. For example, the recharging needs of employees and the recharging needs of occasional visitors, such as customers, will vary: the former will park for a long period of time on a daily basis, while the latter are visiting the facility for a shorter period of time and will likely rely on another primary recharging solution (see section 2.3.3).

Going beyond the differentiation of office buildings within the non-residential building sector (as in the EPBD recast), differentiations could be made within each non-residential building between the use of the building's parking spaces by employees versus non-employees. This way, not only office buildings, but all commercial, leisure and public services buildings would have adapted charging amenities for their employees and their visitors. This implies that each building owner or manager should identify the end use of its parking facilities by user type – at a minimum employee vs non-employee – and install recharging infrastructure accordingly.

The most suitable recharging solution may be different for employees vs. visitors, with slow recharging allowing for a full charge over an eight-hour working day (employee-adapted charging), and faster recharging for occasional, shorter-term visitors. The implementation of recharging facilities for visitors is more likely to be driven by reasons of attractiveness of the facility (commercially-driven), while ensuring charging opportunities for employees pertains to an essential service, without which EV adoption could be severely slowed down.

The recharging infrastructure installation and pre-cabling targets in the EPBD should be higher for parking spaces likely to be used by employees (similar to the 'one-in-two' parking spaces to be equipped in office buildings in the EPBD recast).

Finally, such differentiation could alleviate the concerns of building developers or managers in terms of mandatory recharging infrastructure deployment in their facilities when there is not a commercial case for offering recharging to customers/visitors. It would also ensure targeted deployment of useful recharging infrastructure, giving employees the opportunity to increase their electric car adoption rate.

In conclusion, this policy option prioritises the daily needs of employees who may rely on the recharging infrastructure more than other visitors to the buildings (daily visits for an extended period of time, allowing slow charge), who are likely to have another principal charging solution. As a result, such a policy could address cost and business model concerns of non-residential buildings, while providing the recharging infrastructure that is high in priority and leaves further charging infrastructure deployment (fast, customer-oriented) in those buildings to be market-driven.

HDVs vs. light-duty vehicles

This policy option could include specific provisions for parking facilities associated with buildings that host commercial vehicles (vans, trucks, buses). This would bring buildings dedicated to transport activities (e.g., vehicle depots, logistics centres) explicitly within the scope of Article 12 of the EPBD recast, and would also accelerate the provision of recharging infrastructure adapted to commercial vehicles in buildings with a mixed use of parking facilities

[212] This policy solution approaches the differentiation of provisions for non-residential buildings depending on building type that is in place in Bulgaria, which suggests different recharging infrastructure targets, depending on the building type, for the building as a whole (see section 3.1). The key difference is not to differentiate types of non-residential building by its end use, but to differentiate the use of parking spaces within a non-residential building, e.g. between parking spaces for employees and for visitors.

(e.g., supermarkets with parking spaces for employees, visitors (cars), logistics/deliveries (vans, trucks)). The financial benefits of EVs, on a TCO basis, is usually better for long-mileage vehicles, which makes the adoption of EVs for commercial or professional purposes attractive, provided there are no barriers to accessing recharging infrastructure. EPBD requirements targeting such vehicles may therefore contribute to overcoming this remaining barrier (see section 5.1).

There could be less stringent requirements for short-term parking with high rotation where there would be few smart recharging or bi-directional recharging benefits, and low demand for slow chargers; these parking spots would not be the main locations where such EVs are charged. Conversely, there could be stronger requirements for parking spaces with lower rotation, where vehicles recharge for a longer period of time (e.g., workplace, overnight) and batteries could be used as a distributed electricity resource, and where any recharging infrastructure available could constitute a primary means of recharging for the vehicles using the facility.

Such requirements would need to ensure the implementation of recharging infrastructure with adapted dimensioning, e.g., 50kW charger (minimum) for facilities accommodating buses and trucks in order for the recharging infrastructure to be able to successfully charge the vehicles (e.g., a full recharge overnight). In cases where installation costs would be prohibitive and place a burden on the building owner/manager (e.g., SMEs), exemptions or alternative compliance mechanisms could be designed (see policy option 4).

- *Implement reporting requirements on the number and nature of recharging infrastructure deployed in all buildings falling under provisions of Article 12 of the EPBD recast*

Currently, Member States are not required to do so, although such reporting for public buildings is required under the AFIR. The advantages of such a requirement would be two-fold:

1. Enable the Commission to track and ensure compliance with the EPBD and national transposition;

2. Enable the Commission to collect systematic and reliable statistics within a clear framework (the EPBD, coordinated/harmonised with AFIR reporting requirements) at national and EU level, in an area where data collection on the number of private recharging points has traditionally been very difficult[213].

In order not to place too high a reporting burden on building owners/managers and to ensure smooth collection and compilation of data, the reporting requirements could require, at first and a minima, only the number of chargers deployed and their power rating (e.g. 3.7 kW, 7.3 kW, 22 kW, 50 kW).

- *Strengthen the provisions requiring pre-cabling and implement provisions requiring recharging point implementation in new residential buildings and residential buildings undergoing major renovations (Article 12(4) of the EPBD recast)*

Assuming that Article 12(4) of the EPBD recast is adopted, this policy option aims to accelerate the deployment of recharging infrastructure in new multi-dwelling residential buildings (and those undergoing major renovation). This could, to some extent, avoid having to deploy recharging infrastructure in existing residential buildings (not undergoing any major renovation) at a later stage, where barriers can be much more significant (see **Error! Reference source not found.**). However, with the renovation rate of the building stock in the residential sector currently at under 1% per year (see section 2.3.3), reinforcing recharging infrastructure

[213] For example, the EAFO platform reports only publicly accessible recharging point statistics and data collected from EPBD reporting could be added to the platform. Such reporting would still lack tracking of recharging infrastructure deployment in individual houses.

deployment in new residential buildings and in residential buildings undergoing major renovation, will not be sufficient to significantly increase the access to residential recharging infrastructure in multi-dwelling buildings in the near-term. Therefore, continuous efforts to accelerate the deployment of recharging infrastructure in all existing multi-dwelling residential buildings should be also pursued.

In other words, this policy option can be seen as an (incomplete) alternative to introducing mandatory targets in existing multi-dwelling residential buildings (not undergoing a major renovation) while accelerating the pace of recharging point implementation in multi-dwelling residential buildings. Although the option of introducing mandatory targets in existing multi-dwelling residential buildings (not undergoing a major renovation) was discussed in the focus groups and the workshop, it appeared extremely complex to numerous stakeholders: 'imposing' recharging infrastructure works and recharging point installation in existing residential buildings while explicit demand (i.e. dwellers owning an EV willing to recharge in the building) does not yet exist, potentially leading to significant works and costs for apartment owners/tenants for an under-utilised infrastructure. Such a measure could be particularly difficult in Member States where EV uptake remains very low, and risks creating an unrealistic additional cost burden on households required to contribute to installations they do not need to use. Although anticipating recharging infrastructure deployment so that recharging infrastructure availability is not a barrier to EV adoption is of utmost importance in all other cases, the acceptability and feasibility of systematic recharging infrastructure deployment in existing residential buildings regardless of actual demand seems low, unless innovative financing mechanisms make it possible without placing a undue cost burden on inhabitants (see below).

To guarantee the possibility to recharge for households with a need for it, right-to-plug provisions were created under Article 12(8) of the EPBD recast ('Member States shall remove barriers to the installation of recharging points in residential buildings with parking spaces, in particular the need to obtain consent from the landlord or co-owners for a private recharging point for own use'). This provision and the default approval for a recharging point installation in an existing residential building is extremely important in order not to hold back households wishing to install a recharging point. However, the right-to-plug' principle does not offer all guarantees to EV owners to be able to technically and financially undertake the necessary infrastructure works. The French guidance for recharging point installation in existing residential buildings with multiple co-owners (*copropriété*) was established in 2014 and reinforced in the 2018 *Loi d'Orientation des Mobilités*. It includes some important considerations:

- 'The right-to-plug is conditional on its technical feasibility: in some cases, a collective solution will need to be envisaged to satisfy future demand'.
- '[…] it is preferable to seek in the first place a collective solution.'
- 'In case of an individual demand [for a recharging point], the full installation's responsibility is under the demanding household solely. Thus, the right-to-plug offers the user the possibility to undertake, at their own expense, the necessary works […].'
- 'The right-to-plug offers the possibility to install a recharging point on a private parking space [within a multi-dwelling residential building] but does not specify the conditions of the electrical connection[214].

[214] 1618487546204508 70f6eef474d2fa0a5065e75f36-AVERE_GUIDE_INTERACTIF_15042021.pdf (avere-france.org) [translation by the author].

Right-to-plug by no means guarantees that the demanding household will be able to technically and financially undertake the infrastructure works necessary to install an individual recharging point.

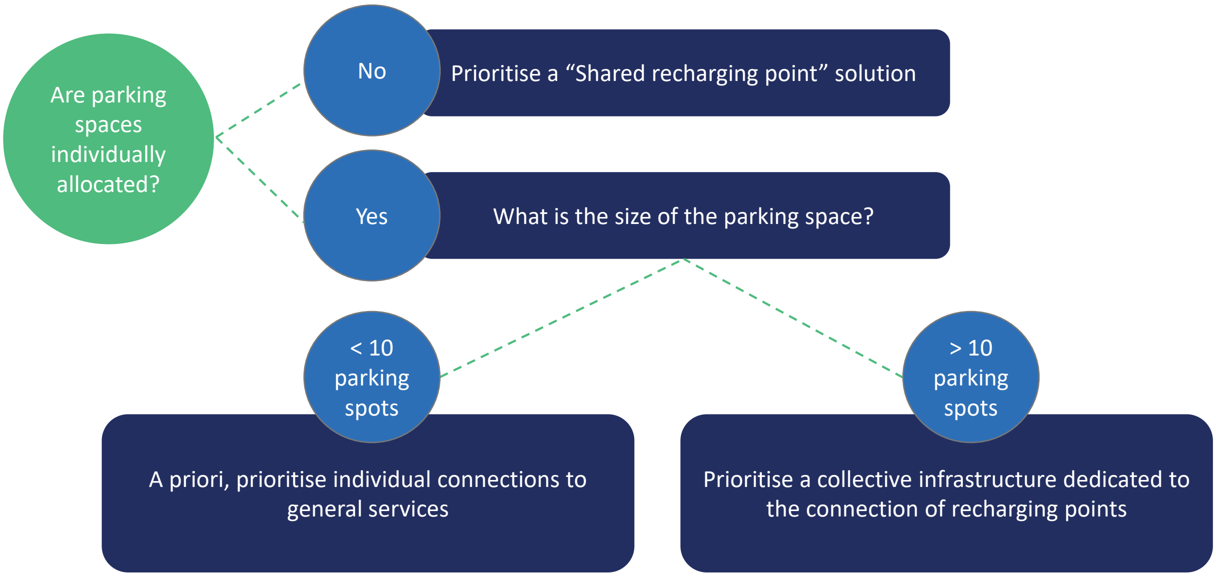
The works undertaken by the first household may facilitate/allow the later connection of other parking spaces within the building, but this is not guaranteed. If future connections were not anticipated during the primary works, this may eventually lead to a likely more complex and higher overall cost of equipping the entire building than if the works had been undertaken collectively. It also poses the question of who bears the cost of the infrastructure works, in particular at inception.

Additional solutions should be envisaged to facilitate the deployment of recharging infrastructure in existing multi-dwelling residential buildings without encountering the following two opposed barriers:

- A collective infrastructure cost to be borne by all building's residents/owners, even when many of those do not have an immediate use of the recharging infrastructure;
- An individual infrastructure cost to be borne solely by the first demander and that may not be fit for future extension into a collective infrastructure.

In addition, there is a diversity of recharging infrastructure architectures for buildings (see section 2.), which would benefit from being anticipated by all building residents, even when not yet equipped with an EV (see Figure 21).

Figure 21: Guidance for decision-making on type of installation of recharging points in multi-dwelling buildings (AVERE France)



Source: 1618487546204508706eef474d2fa0a5065e75f36-AVERE_GUIDE_INTERACTIF_15042021.pdf (avere-france.org) [Visual reproduced and translated by the author].

The policy option may help to initiate the installation of the first recharging points during building construction or major renovation, facilitating decision-making for:

- the later installation of additional recharging points (as demand grows);
- the early implementation of the most suitable architecture for the building's recharging system.

Additional policies facilitating the implementation of collective infrastructure in existing multi-dwelling residential buildings could be researched and developed, along with innovative cost-sharing mechanisms to overcome the two main barriers. Beyond individual financial incentives, one solution could be to offer cost-sharing guarantees/mechanisms (supported by an adequate article in the EPBD): the cost of early optimised infrastructure works that would later serve all the buildings' residents could be borne by a third-party (e.g. the DSO, the state, a charging infrastructure operator) until critical mass is attained in charging point demand in the building. Infrastructure costs can then be shared between residents at a later stage once this 'critical mass' is attained.

One final means of strengthening provisions is to require recharging points for electric two-wheeled vehicles (mopeds and motorcycles) to be made available.

- *Eliminate or revise the exemptions under Article 8(6)c and Article 8(4) of the EPBD from 2018*

Article 8(6)c states: 'Member States may decide not to apply paragraphs 2, 3 and 5 to specific categories of buildings where […] the cost of the recharging and ducting installations exceeds 7% of the total cost of the major renovation of the building.'

Article 8(4) states: 'Member States may decide not to lay down or apply the requirements referred to in paragraphs 2 and 3 to buildings owned and occupied by small and medium-sized enterprises as defined in Title I of the Annex to Commission Recommendation 2003/361/EC'.

These exemptions concern a ceiling of expenditures for recharging infrastructure installation (7% of the total cost of the major renovation of the building) and SMEs. Section 3 has identified that it is by far the most commonly used exemption.

These exemptions have been removed from the EPBD recast. In cases where the cost burden of implementing the EPBD provisions of paragraphs 2, 3, 4, 5 (those that lay down numerical recharging infrastructure deployment targets and requirements) is prohibitive, any exemption could be accompanied by an alternative compliance option.

For example, if the 7% exemption were to remain in the EPBD, it could be accompanied by a justification obligation requiring the building developer to make a contribution equal to 7% of the total cost of the major renovation of the building to a local fund (local municipality, region) for the deployment of on-street/publicly accessible recharging infrastructure (not directly associated with the building benefiting from the exemption). This way, when the recharging infrastructure works at major renovation are estimated to be larger than 7% of the overall works, the constructor/renovator can save the difference (and avoid an overly large additional financial burden) while still contributing to the deployment of recharging infrastructure. This ensures a fair distribution of the cost burden for recharging infrastructure deployment between all buildings undergoing major renovation. Collaboration between the building's owner/manager and local authorities could be envisaged to be even closer so as to organise, with the 7% allocated budget, the deployment of recharging infrastructure in the immediate vicinity of the building. If this exemption is not simply removed, as suggested in the EPBD recast, mandating such an alternative would encourage building owners/managers to consider all feasible ways to deploy recharging infrastructure within their building, and ensure the securing of funds and the deployment of recharging infrastructure in the area, should in-building recharging infrastructure not be implementable.

Another alternative compliance option may be to require the installation of additional bike parking spaces in the building undergoing major renovation, instead of the deployment of costly recharging infrastructure. The point of designing alternative compliance mechanisms, regardless of the nature of the alternative itself, is to ensure the contribution of all buildings towards sustainable mobility and avoid undue recourse to exemptions. Such a mechanism (financial contribution of building owners/managers towards sustainable mobility infrastructure deployment) may also apply to buildings without parking lots, which are currently not subject to the EPBD recharging infrastructure requirements.

For SMEs (relative to Article 8(4)), ways to involve the building owner/manager in the deployment of recharging infrastructure locally should be explored, with solutions tailored depending on the local needs of recharging infrastructure deployment, in particular recharging infrastructure dedicated to light-duty vehicles or to HDVs, and taking into account the vehicles' mission profile.

Goal: Facilitating the process to deploy recharging infrastructure

- *Include, as part of Article 12(8) of the EPBD recast, provisions requiring Member States to implement single national/local one-stop-shops (e.g. institutional entity, website) for process and legal guidance and assistance to in-building recharging infrastructure deployment for owners, tenants and users of parking spaces in buildings*

This includes assistance with navigation of local laws, regulations and permitting processes, by type of situation and applicant (e.g. apartment owner, building owner, tenant, SME), and information to support customers to navigate incentives. Specific guidance may also be provided to low-income households.

This involves facilitating and simplifying the deployment of recharging points in new and existing residential and non-residential buildings, which is the point of Article 12(8) of the EPBD recast. It would increase process transparency and ease of finding information, as well as facilitating the identification of available assistance for tenants and owners wishing to install recharging points, making the requirement of Article 12(8) of the EPBD recast – 'to ensure the availability of technical assistance' – more concrete. Given the complexity of deploying recharging infrastructure in existing multi-dwelling residential buildings according to present and future needs (see policy option 3), adopting policy option 5 could constitute an additional facilitating element.

Goal: Ensuring future-proof installations

- *Adopt Article 12(6) of the EPBD recast (Member States shall ensure that […] recharging points […] are capable of smart charging, and where appropriate, bi-directional charging)*[215]

Table 17 complements **Error! Reference source not found.** and lists the positives and negatives of each shortlisted policy option. These pros and cons were in part informed by stakeholders attending the policy workshop.

[215] See policy option 'Require all installations (from pre-cabling to recharging point installation) to be V2G (i.e. bi-directional)-capable' in **Error! Reference source not found.**, and associated comments.

Table 17: Analysis of shortlisted policy options

Policy recommendation[216]	Pros	Cons	Additional context/comments
1. In non-residential buildings, differentiate EPBD provisions by user profile of parking facilities (in Article 12(1) and Article 12(2) of the EPBD recast)	- Charging infrastructure requirements that are fit for purpose would help to better match supply to demand, improving the cost-effectiveness of recharging point deployment - Long-stay parking requirements could yield V2G benefits in the future - Ensures the deployment of charging infrastructure adapted and dedicated to employees - Inclusion of specific provisions for commercial and HDVs would lower barriers to access recharging infrastructure for this category of vehicles	- May be difficult to normalise user profiles on an EU-wide basis - Creates an additional degree of complexity for buildings with mixed used function and service types - Would lead to more prescriptive rules than under the EPBD and in the EPBD proposal	Requirements for solar-ready buildings should be coupled with requirements for recharging pre-cabling. Vehicle owners and users should be clearly informed on how to reap the benefits of EVs flexibility
2. Implement reporting requirements on the number and nature of recharging infrastructure deployed in all buildings falling under provisions of Article 12 of the EPBD recast	- Consistent with the EPBD recast requiring energy performance certificates (EPCs) to include information on building recharging infrastructure, as well as to develop mandatory databases for EPCs - Allow the European Commission to better track overall market progress and update policie; - Constitutes an indirect incentive for Member States to implement policies and measures to deploy recharging infrastructure in private buildings - Already done in some Member States through the tracking of subsidies (e.g.	- Increased administrative burden for Member States and building owners/managers	A seamless reporting process and a simple and clear reporting scope (e.g. only number and power rating of charging points installed) could ease the additional administrative burden for all parties

[216] See Table 16 for barriers associated with each policy option.

Policy recommendation[216]	Pros	Cons	Additional context/comments
	Advenir programme in France requires reporting)		
3. Strengthen the provisions requiring pre-cabling and implement provisions requiring recharging point implementation in new residential buildings and residential buildings undergoing major renovations (Article 12(4) of the EPBD recast)	Aims to (partially) alleviate the need for recharging infrastructure deployment in existing multi-dwelling residential buildings (not undergoing major renovation) at a later stage. Its advantages relative to recharging point installation 'from scratch' in existing buildings are: - Would minimise lost opportunities (once a new building is built or a renovation complete, it will be harder to require a property owner to install charging points) - Decrease effort for property owners and tenants (installing recharging points would not be a separate project to deal with in each individual case) - Decrease costs (lower transaction costs if recharging point installation is part of wider construction/work contract for a whole parking lot instead of individual parking spaces) - Lower administrative burden for local governments	- Does not cover existing buildings not undergoing major renovations	- Requirements for solar-ready buildings should be coupled with requirements for recharging pre-cabling - Given the main drawback of this policy option and in order to accelerate recharging infrastructure deployment in all multi-dwelling residential buildings, primarily in existing multi-dwelling residential buildings not undergoing major renovation, additional measures are likely to be needed (e.g. further streamlining decision-making and permitting process, enhancing access to and transparency of information, implementing innovative cost-sharing mechanisms) (see in-text discussion of policy option 3)
4. Eliminate or revise the exemptions under Article 8(6)c and Article 8(4) of the EPBD from 2018	- Eliminating the 7% exemption would end several market distortions it potentially causes: ▪ For example, a building with a large parking lot is more likely to be exempted than a building of the same size with a small parking lot - this means the buildings with the highest volumes of potential EV charging points would be exempted. Another issue is	- Political repercussions or backlash from Member States (section 3 identified this exemption as most commonly used by Member States) - Potential complexity in dealing with and implementing some	The exemptions should not lead to 'all or nothing' situations: instead of full exemptions or fully alternative compliance mechanisms, installations could also be also done at least for a cost up to 7% of the total cost, even if it leads to only partial equipment of the building

Policy recommendation[216]	Pros	Cons	Additional context/comments
	that a more expensive building with a parking lot is more likely to have recharging points installed than a comparable, but less expensive, building with a comparable parking lot ▪ This exemption could result in a price ceiling for contractors installing recharging infrastructure, making it less likely they will bid on projects covered by the EPBD ▪ For building owners looking to cut costs, the exemption could give them an incentive to accept the highest bid for installing recharging points (allowing them to invoke the 7% rule) - All buildings with parking facilities should contribute to charging infrastructure deployment – if not through own installation of charging points, through a sensible alternative compliance mechanism	advanced alternative compliance mechanisms	
5. Include, as part of Article 12(8) of the EPBD recast, provisions requiring Member States to implement single national/local one-stop-shops (e.g. institutional entity, website) for process and legal guidance and assistance to in-building charging infrastructure deployment for owners, tenants and users of parking spaces in buildings	- Increases transparency and serves all potential and existing EV users, including hard to reach populations (e.g. low income, SMEs) - Unifies processes and guidelines at local/national level	- Increases the EPBD-compliance burden for Member States	The one-stop shops may also cover PV installations to ensure combined and optimal deployment of PV and recharging in symbiosis
6. Adopt Article 12(6) of the EPBD recast (Member States shall ensure that […] recharging points […] are capable of smart charging, and where appropriate, bi-directional charging)	- Ensuring smart charging infrastructure from the start is less costly than installing dumb infrastructure and later having to add smart chargers or smart features - Cost savings for EV users (via time of use	- When the revised EPBD comes into force (after 2025), it is quite likely that smart charging will already be a default function, weakening the impact of	It can be more beneficial to EV owners to use electricity from on-site solar panels rather than exporting it to the grid. If smart charging is combined with rooftop solar, users can make optimal use of their own power generation,

Policy recommendation[216]	Pros	Cons	Additional context/comments
	rates, demand response, etc.) - Grid benefits, including flexibility to reduce peak load, voltage control, deferred infrastructure upgrades - Energy cost savings, including lower wholesale and retail prices from smart charging (and from V2G where appropriate)[217]	this article	further reducing their energy bills[218]

[217] https://www.raponline.org/knowledge-center/time-is-now-smart-charging-electric-vehicles
[218] Ibid.

Other points of discussion and potential improvement of the EPBD, including aspects mentioned in the longlist but not retained for the shortlist (see section 5.2) have been discussed throughout this project and may merit further attention.

Formulation of the numerical targets in the EPBD

The numerical targets for charging points in the EPBD are currently expressed on a 'per parking space' basis, and the number of parking spaces themselves are based on building codes' provisions (minimum car parking requirements in buildings). This type of target formulation takes a car-centric view that may no longer be in line with sustainable mobility objectives, i.e. it assumes that as more parking spaces are built (and reliance on cars grows), more recharging infrastructure will be built. Conversely, if fewer parking spaces are built, less recharging infrastructure is deployed. Such a target formulation does not allow for the simultaneous reduction of car parking spaces and reorganisation of cities and living areas to guarantee similar mobility opportunities (e.g. making space for bikes, public transport, walking) with maximising the recharging infrastructure coverage of existing car-parking facilities.

Alternative forms of targets formulation may be envisaged, as in the AFID proposal, where indicative on-road recharging infrastructure deployment targets have been changed from a 'recharging point per EV' basis to a 'kW installed per EV' basis. It is uncertain whether the same metric could be adapted in the context of the EPBD, as within the specific context of buildings, it can be difficult to deploy recharging infrastructure following a continuous EV adoption curve. This may be less cost-effective than deploying new charging infrastructure during new builds and renovation works.

Recharging infrastructure targets based on 'kW installed per EV', on a 'per m^2' basis, on a 'per occupant' basis, on a 'per household' basis, or on any other potentially relevant metric, could be further explored for effectiveness and relevance. However, pre-cabling should probably continue to be deployed on a 'per parking space' basis, to ensure the possibility to select the parking spots associated with recharging points and retain flexibility as to the number and location of chargers in the future.

Simultaneous use of recharging points

The EPBD recast proposal includes, for new buildings and buildings undergoing major renovation (both residential and non-residential), the requirement that 'Member States shall ensure that the pre-cabling is dimensioned so as to enable the simultaneous use of the expected number of recharging points'.

Ensuring adequate dimensioning of the recharging installation is an important point. However, this provision does not specify what 'simultaneous use' encompasses, nor the minimum charging power involved. The City of Oslo, for example, requires that 'the grid capacity in new buildings must be designed to charge at 3.6 kW all of the vehicles in the building without any need for smart charging to prevent local power shortages' (see section 5.2). While taking a position on the minimum mandated charging power is delicate (it may vary by Member State/region), the very requirement of 'simultaneous use' may also be challenged at large-scale EV adoption rates, where delayed recharging, smart recharging and queuing mechanisms at building level may be beneficial both for consumers (in terms of cost) and for the electricity system as a whole (in terms of cost, peak capacity needs and CO_2-intensity of electricity generation).

Finally, this provision applies in Article 12(1) and Article 12(4) of the EPBD recast proposal, i.e., for new non-residential buildings and non-residential buildings undergoing major renovation, as well as new residential buildings and residential buildings undergoing major renovation. It may also be relevant under Article 12(2) for existing non-residential buildings. Perhaps formulating the requirement as 'Member States shall ensure that the pre-cabling is dimensioned so as to cover the expected recharging needs of all recharging point users within the building' could be an alternative worth further considering – ensuring that recharging needs are covered is the end goal of the recharging infrastructure installation, and this avoids the use of unacceptably low power ratings per charger, while allowing the possibility for smart recharging and queuing mechanisms.

Definitions

A better common understanding of definitions relative to Article 12 of the EPBD recast could be valuable, such as 'pre-cabling', 'adjacent', 'simultaneous use' and 'right-to-plug'. These terms are not part of the EPBD recast Article 2, on definitions. Terms subject to interpretation by Member States may create important divergences in their transposition of the EPBD at national level. Lack of clarity of definitions of some of these terms was noted by a number of stakeholders throughout the project. For example, AVERE suggests the following definition for 'pre-cabling': 'includes all measures that are necessary to enable the installation of recharging points at a later date. This includes cable routes, space for transformers and electricity meters as well as grid capacities'[219]. Another definition was proposed by ACEA, 'pre-cabling of buildings should mean both the technical cabling (cable path, technical sheaths, drilling) and the electrical pre-equipment in collective electrical installations (switchboard, horizontal electrical column, bus cable)'[220].

[219] https://www.avere.org/wp-content/uploads/AVERE-Reaction-paper-revised-Energy-Performance-of-Buildings-Directive-EPBD.pdf
[220] ACEA, Recast of Energy Performance of Buildings Directive (EPBD) - ACEA - European Automobile Manufacturers' Association, June 2022

ANNEX X1: IMPACT ASSESSMENT METHODOLOGY

This annex describes how the supply of charging infrastructure as a result of the expected implementation of the EPBD was calculated.

Some of the terms used in the EPBD proposal were defined in order to operationalise them for this study, i.e. 'non-residential' and 'residential' and 'parking space'. The term 'major renovation' is defined in Article 2(10) of the EPBD[221]. With regard to the term 'parking spaces', according to the EPBD proposal this concerns parking spaces 'in car parks in and adjacent to buildings'. A clarification of the notion of 'car parks' is necessary, however, as not every parking space is located in a car park. This also applies to when a car park is considered 'adjacent to a building'.

The Commission's Recommendation on Building Modernisation[222] provides further clarification of these terms. Table 18 shows how the different definitions are described in the Recommendation on Building Modernisation and subsequently operationalised in this study.

Table 18: Interpretation of relevant definitions in the EPBD proposal for this study

Definition	Commission Recommendation on Building Modernisation	Operationalisation for the study
Residential	*'"Residential" should be interpreted as including single-family and multi-family dwellings'*	As defined in the European Building Stock Database and subdivided into the following categories: single-family dwellings multi-family dwellings with < 10 dwellings multi-family dwellings with > 10 dwellings
Non-residential buildings	*"Non-residential" includes buildings that are used for a purpose other than residential (i.e. office buildings, healthcare buildings, wholesale and retail trade buildings, educational buildings, hotels and restaurants, etc.)'*	As defined in the European Building Stock Database and subdivided into the following categories: Offices Wholesale and retail trade buildings, Educational Tourism (including hotels and restaurants) and healthcare Others (e.g. sports facilities)
Car park	*'[…] within the context of the EPBD, "car park" should exclude on-street parking located on public roads, for example'*	Off-street parking spaces in buildings (as opposed to on-street parking spaces and off-street parking spaces not in buildings, e.g. in airports)
Adjacent to the building	*'[…] situations where the car park is not strictly speaking physically adjacent to the building […] but it has a clear link with the building in terms of ownership and/or usage'*	Parking space that should belong to a building on the basis of parking norms assigned to the function of the building and which are located off-street

[221] 'Major renovation' means the renovation of a building where: (a) the total cost of the renovation relating to the building envelope or the technical building systems is higher than 25% of the value of the building, excluding the value of the land on which the building is situated; or (b) more than 25% of the surface of the building envelope undergoing renovation. Member States may choose to apply option (a) or (b).
[222] Commission Recommendation (EU) 2019/1019 of 7 June 2019 on building modernisation.

Having operationalised relevant definitions in the EPBD proposal, different datasets need to be merged in order to estimate the charging infrastructure expected to be realised under the EPBD proposal. Information is needed on four aspects:

- Total current and future building stock per building type;
- Number of parking spaces per 100m^2, per building type;
- Share of building types with more than three, five and 20 parking spaces;
- Average major renovation rate.

Part of the necessary data is available in the impact assessment report accompanying the EPBD proposal, Annex I[223]. Firstly, data on the total floor area of different buildings in Europe is needed. Table 19 presents the projected development in floor aream by building categories.

Table 19: Floor area (per building type) in million square meters[224]

Building type	2020	2025	2030	2050
Residential				
House	11,060	11,427	11,808	13,495
Multi-family buildings <10 dwellings	2,929	3,010	3,093	3,495
Multi-family buildings >10 dwellings	3,818	3,934	4,055	4,594
Non-residential				
Office buildings	1,501	1,574	1,653	2,026
Wholesale and retail trade	1,486	1,561	1,642	2,029
Others (e.g. sports facilities)	905	950	997	1,225
Tourism/healthcare (including restaurants)	1,304	1,365	1,429	1,728
Educational buildings	1,111	1,169	1,230	1,527

The impact assessment report for the EPBD proposal also provides information on the number of parking spaces per 100m^2, per building type. According to Guidehouse, which made the calculations in Annex I, these figures were compiled on the basis of expert judgement. This also applies to the assumptions related to the share of building types with more than five, 10 and 20 parking spaces. In addition, the figures in Annex I do not include any assumptions about the number of buildings with more than three parking spaces[225], nor is a distinction made between on-street and off-street parking.

Considering these limitations, figures on parking spaces were enriched by empirical research. The number of parking spaces per 100m^2, per building type are based on parking norms used in various municipalities in Germany, Spain, the Netherlands and the UK.

[223] European Commission, Impact assessment report accompanying the proposal for a Directive of the European Parliament and of the Council on the Energy Performance of Buildings (recast), SWD(2021) 453.

[224] Ibid, Annex I.

[225] At the time the impact assessment report was published, the relevant obligation applied to non-residential buildings with more than five parking spaces, instead of the current proposal of more than three parking spaces.

Although these data come from Western European countries, the figures are considered to reflect the EU as a whole, because car ownership in these countries is around the European average. Parking spaces are a derivative of parking demand, which depends on the average number of cars per inhabitant. A correction for the share of parking spaces that are located on-street (thus out of scope of the EPBD) is applied to the parking norms. Based on a mobility survey carried out by the Joint Research Centre (JRC) of the European Commission[226], the share of off-street parking is estimated at 47%[227]. The share of building types with three, five and 20 parking spaces are based on the average building sizes that are found in the European Building Stock database.

Two scenarios with different assumptions have been defined:

- Scenario 1 uses the assumptions on parking spaces, enriched with more empirical data on parking norms and additional data on average building size;
- Scenario 2 uses the same assumptions on parking spaces as in the EPBD proposal impact assessment report.

Table 20 and Table 21 show the assumptions behind the two scenarios. In the absence of better data, the assumptions on the building shares for residential buildings in scenario 2 were adopted in scenario 1.

Table 20: Assumptions on parking spaces in scenario 1

Building type	Number of parking space per 100m²	Share of buildings with more than 3 parking spaces	Share of buildings with more than 5 parking spaces	Share of buildings with more than 20 parking spaces
Residential				
House	0.7	0%	0%	0%
Multi-family buildings <10 dwellings	0.9	70%	50%	0%
Multi-family buildings >10 dwellings	0.9	100%	100%	50%
Non-residential				
Office buildings	0.8	-	87%	46%
Wholesale and retail trade	1.8	-	89%	56%
Others (e.g., sports facilities)	1.3	-	97%	90%
Tourism/healthcare (including restaurants)	1.1	-	90%	59%
Educational buildings	0.5	-	87%	49%

[226] Pasaoglu Kilanc, G., Fiorello, D., Martino, A., Scarcella, G., Alemanno, A., Zubaryeva, A. and Thiel, C., Driving and parking patterns of European car drivers – a mobility survey, 2012.
[227] Based on an average of: ES, 39%; PL, 40%; IT, 49%; DE, 57%; FR, 55% and UK, 39%.

Table 21: Assumptions on parking data in scenario 2, based on the assumptions in the impact assessment report for the EPBD proposal

Building type	Number of parking space for 100m²	Share of buildings with more than 3 parking spaces	Share of buildings with more than 5 parking spaces	Share of buildings with more than 20 parking spaces
Residential				
House	1.25	0%	0%	0%
Multi-family buildings <10 dwellings	1.25	70%	50%	0%
Multi-family buildings >10 dwellings	1.25	100%	100%	50%
Non-residential				
Office buildings	1	-	75%	25%
Wholesale and retail trade	1	-	60%	25%
Others (e.g., sports facilities)	1	-	60%	25%
Tourism/healthcare (including restaurants)	1	-	80%	38%
Educational buildings	1	-	80%	38%

Scenario 1 shows that certain buildings have more parking spaces than others. For example, buildings that attract more visitors per square metre, such as wholesale and retail trade buildings, have higher parking standards per unit floor area than buildings that attract fewer visitors per square metre, such as universities and hospitals.

Only the results of the first scenario are discussed in section 2, as it is based on better-founded assumptions. The results of scenario 2 are included in Annex X2.

Finally, it is necessary to make assumptions on the average major renovation rate. This used the assumptions applied in the impact assessment report for the EPBD proposal (Table 22). The renovation rate figures are consistent with the Renovation Wave Strategy and the EPBD targets, thus the results are dependent on the extent to which the renovation targets are met.

Table 22: Assumptions on major renovation rate

Building type	Average major renovation rate
Residential	
House	1.50%
Multi-family buildings <10 dwellings	1.50%
Multi-family buildings >10 dwellings	1.50%

Building type	Average major renovation rate
Non-residential	
Office buildings	2.70%
Wholesale and retail trade	2.70%
Others (e.g. sports facilities)	2.70%
Tourism/healthcare (including restaurants)	2.70%
Educational buildings	2.70%

ANNEX X2: IMPACT OF THE EPBD PROPOSAL ON THE E-MOBILITY MARKET SCENARIO 2 RESULTS

This annex shows the key results using the same assumptions as in the previous EPBD impact assessment report.

Residential buildings

Figure 22: Market share of demand for charging points in residential buildings affected by EPBD proposal measures at a given moment

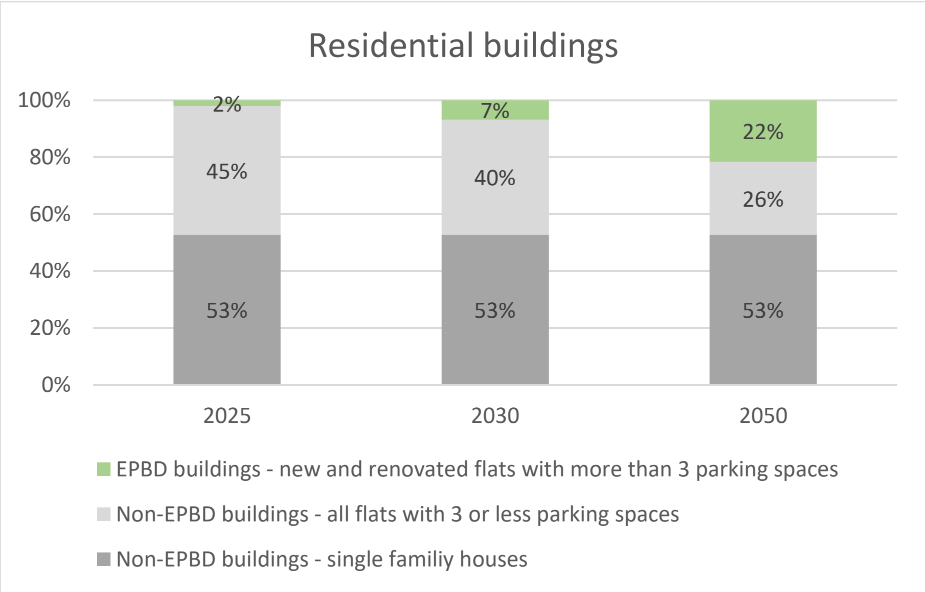
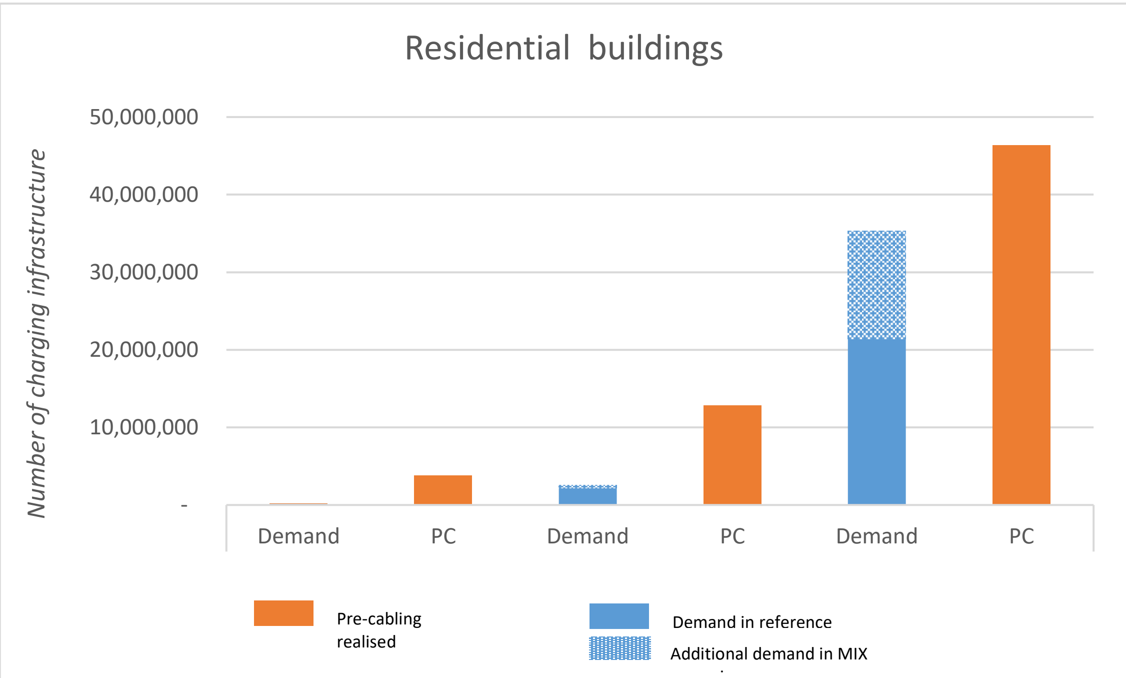
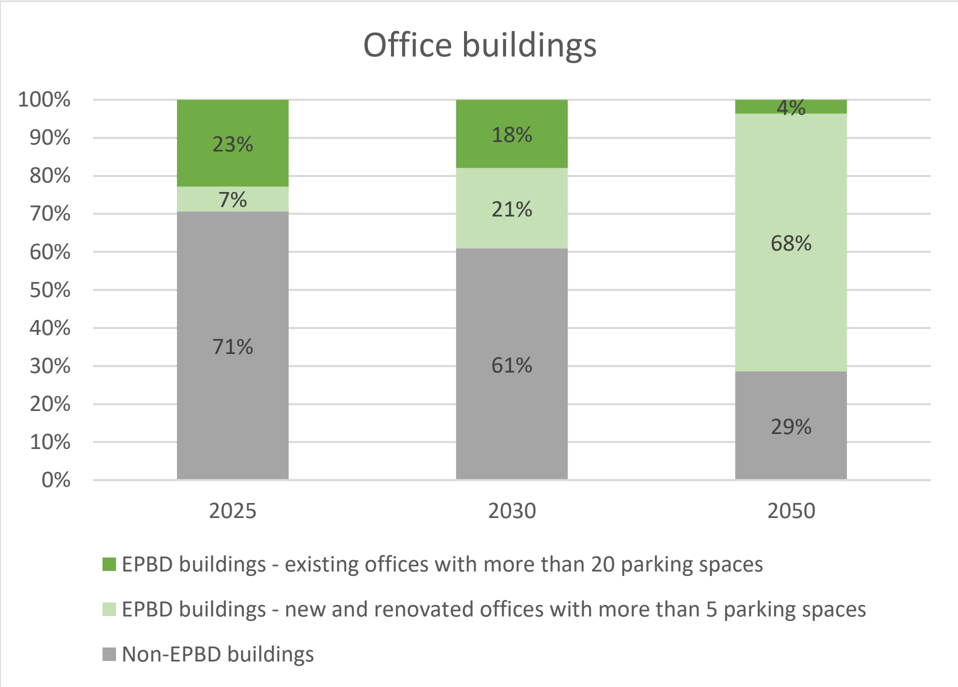


Figure 23: Comparison of supply and demand of charging infrastructure in residential buildings within scope of the proposed EPBD



Office buildings

Figure 24: Market share of demand for charging points in office buildings affected by EPBD proposal measures at a given moment



New and renovated offices with more than five parking spaces

Figure 25: Comparison of supply and demand of charging infrastructure in new and renovated office buildings within scope of the EPBD proposal

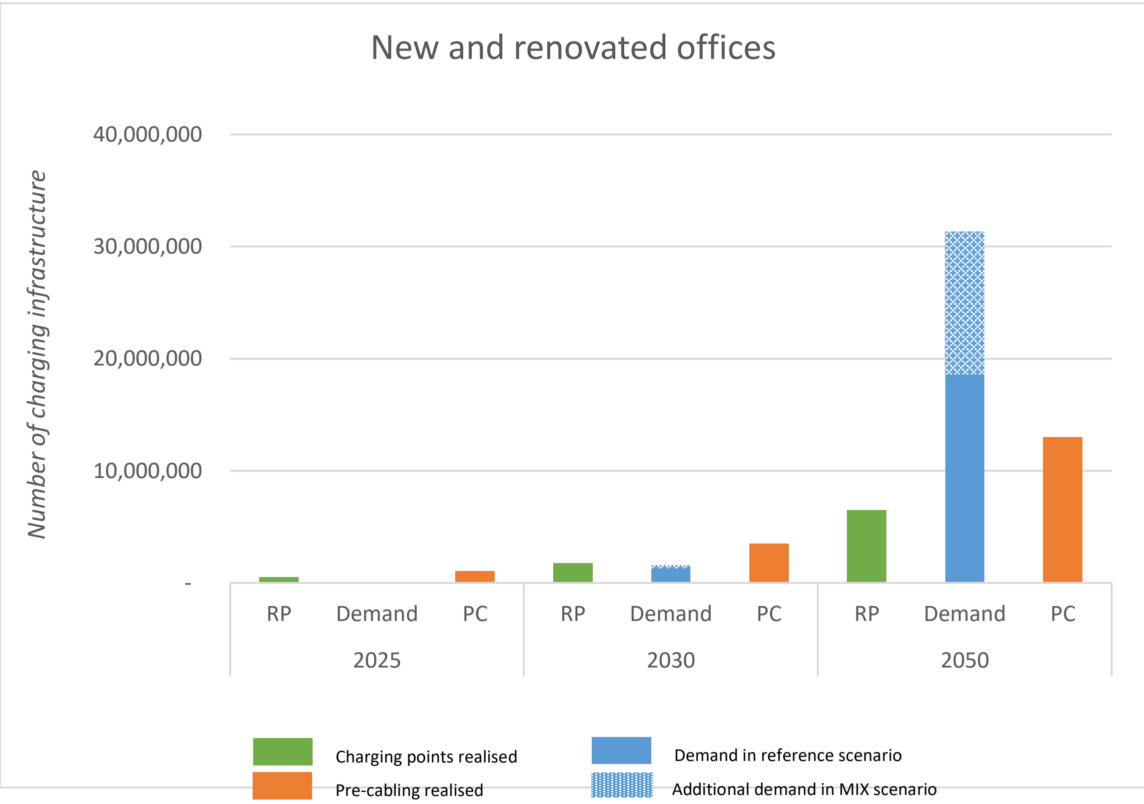
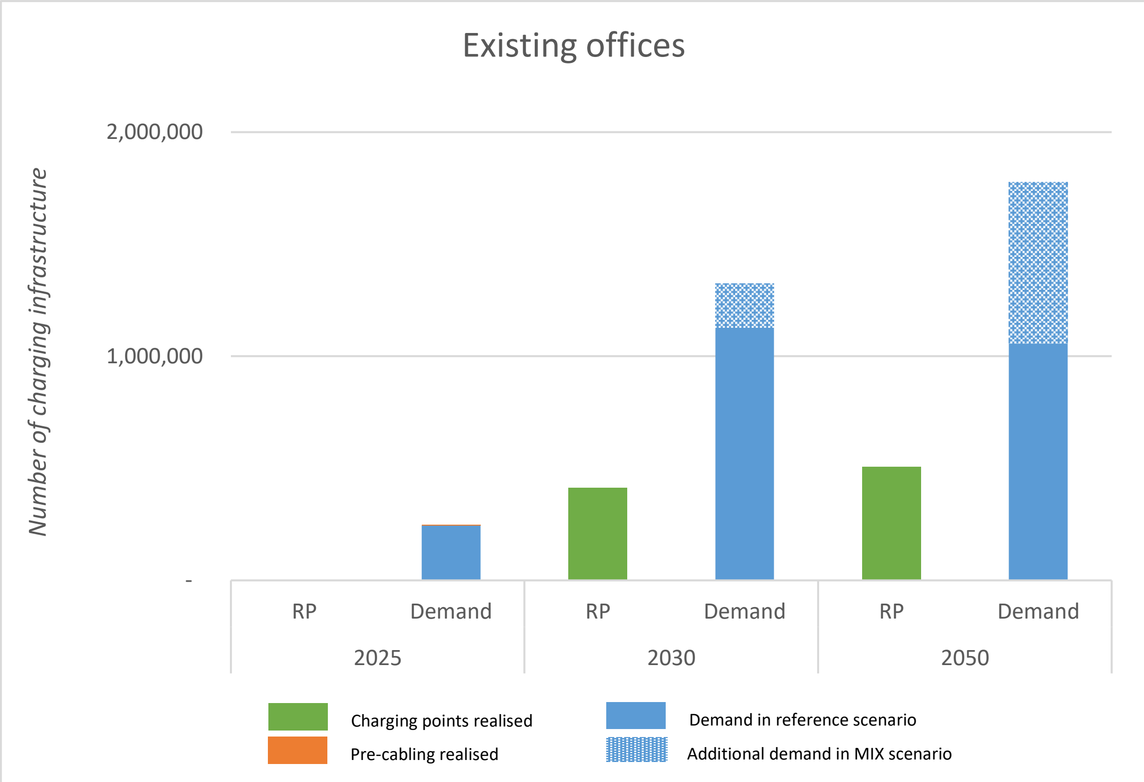


Figure 26: Comparison of supply and demand of charging infrastructure in existing office buildings within scope of the EPBD proposal



Non-residential buildings

Figure 27: Market share of demand for charging points in non-residential buildings (excluding offices) affected by EPBD proposal measures at a given moment

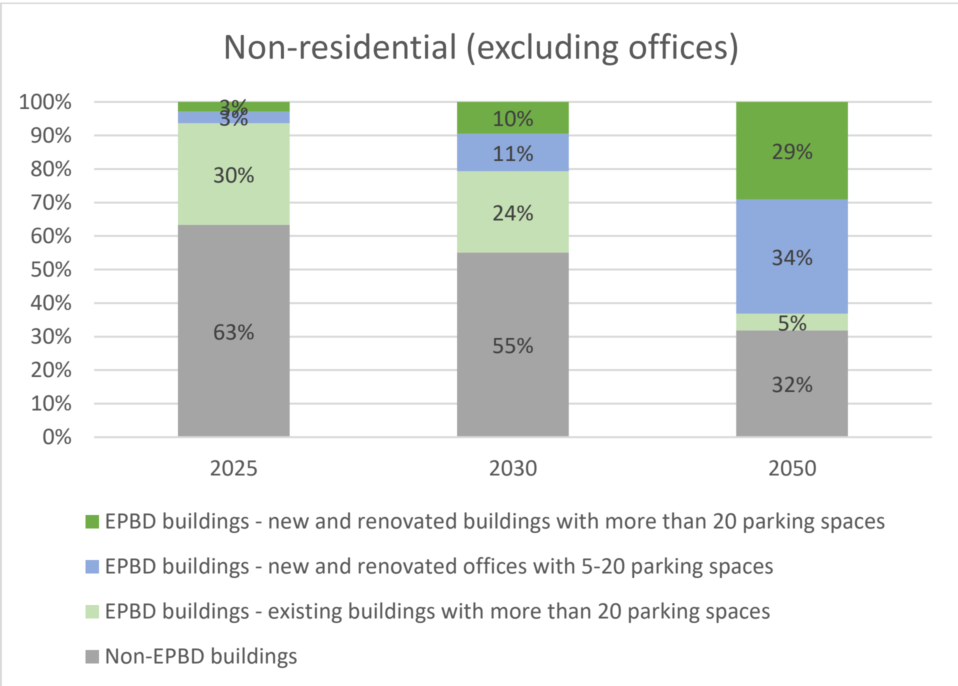
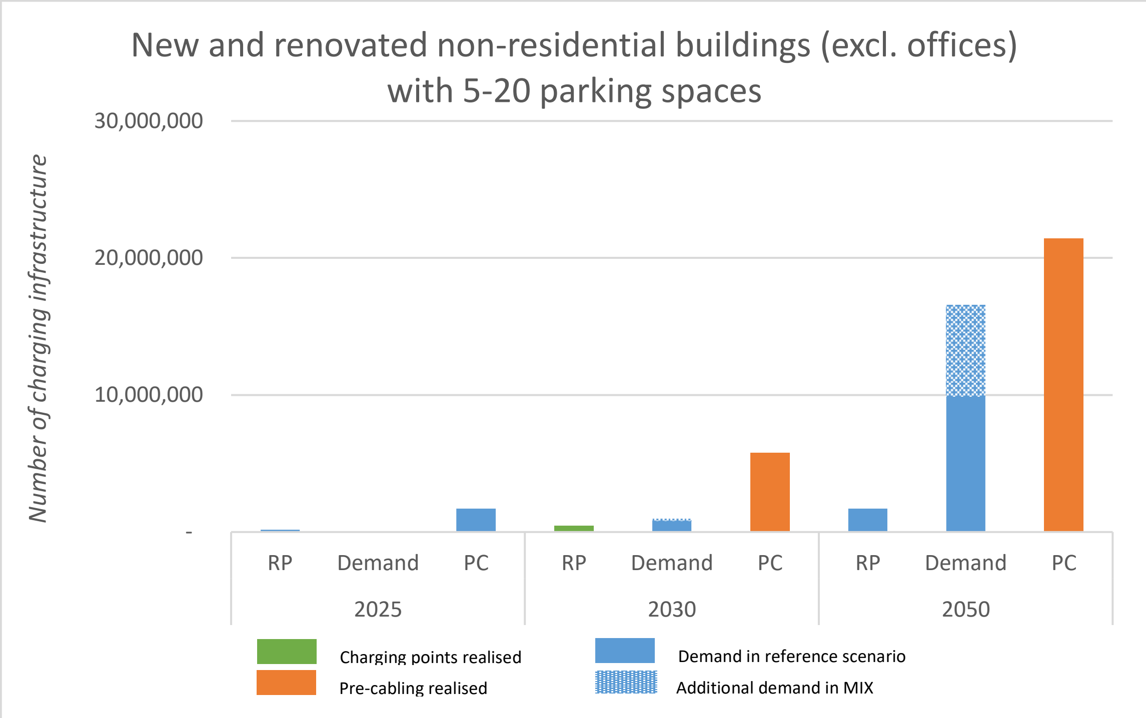
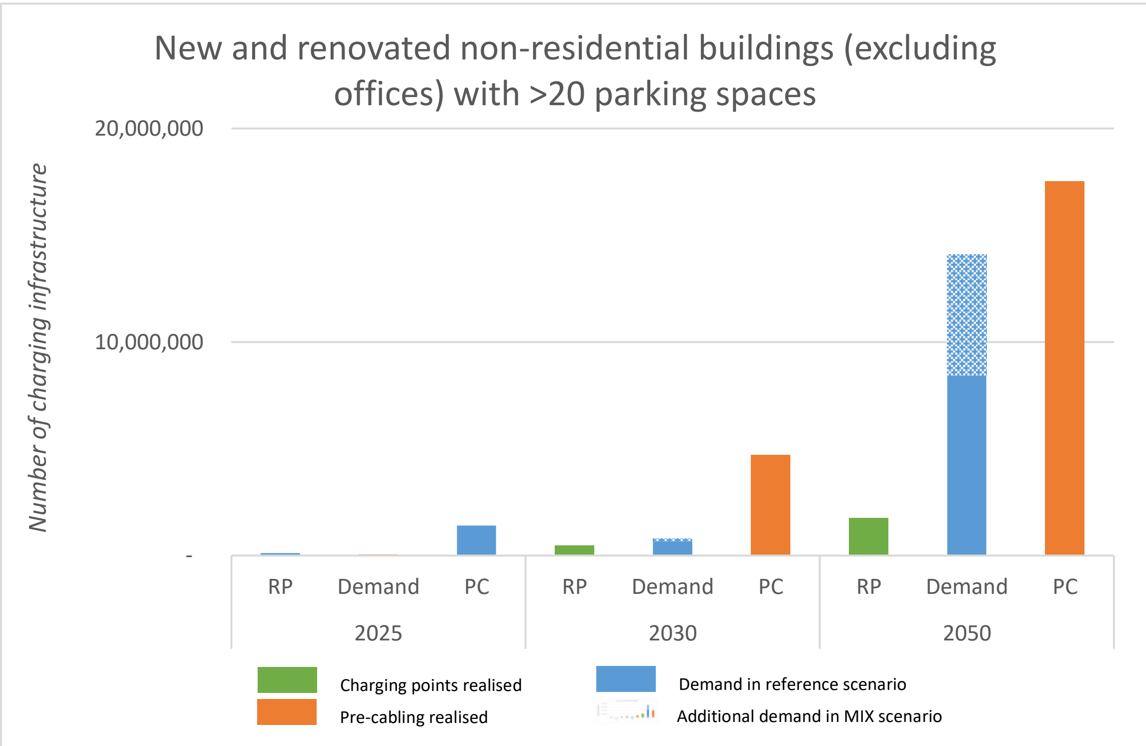


Figure 28: Comparison of supply and demand of charging infrastructure in new and renovated non-residential buildings within scope of the EPBD proposal (excluding offices) with more than 5 and less than 20 parking spaces



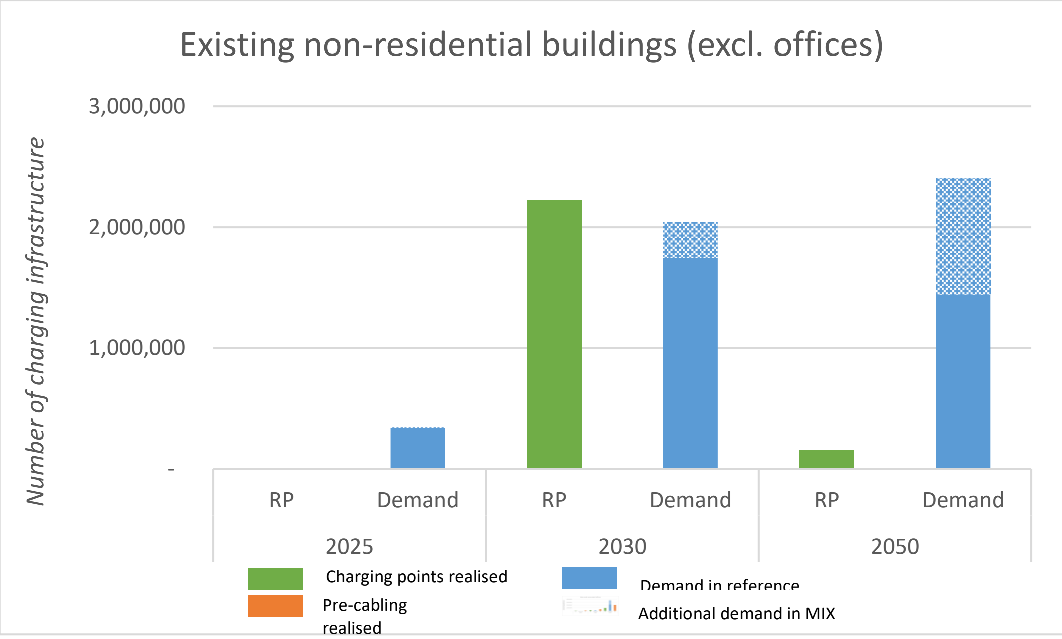
New and renovated non-residential buildings (excluding offices) with more than 20 parking spaces

Figure 29: Comparison of supply and demand of charging infrastructure in new and renovated non-residential buildings within scope of the EPBD proposal (excluding offices) with more than 20 parking spaces.



Existing non-residential buildings (excluding offices) with more than 20 parking spaces

Figure 30: Comparison of supply and demand of charging infrastructure in existing non-residential buildings within scope of the EPBD proposal (excluding offices) with more 20 parking spaces



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