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PART 3/4

COMMISSION STAFF WORKING DOCUMENT

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}

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Annex F: Minimum energy performance standards (MEPS)

1. Introduction on MEPS

1.1. Definitions

For a clearer understanding of the policy options related to minimum energy performance standards it is useful to clarify some definitions.

"Minimum energy performance standards" are understood in this document as regulations or policies that require buildings to meet some performance benchmark, expressed as energy performance rating, often giving building owners multiple years to bring buildings into compliance.

"Mandatory" energy codes or standards (or other policies) have provisions that are legally binding; non-compliance could lead to financial penalties being imposed.

In the literature other similar definitions have been presented. For instance, the "Lessons learnt" study[1] defines "minimum mandatory requirement"[2] as "a regulation that mandates certain buildings within a defined territory to meet a certain performance standard, by a specified compliance date or according to natural trigger points in the building's lifecycle (e.g. time of sale). The requirement can apply to all buildings or particular building segments. The underlying metrics of the requirement is typically based on energy performance standards (kWh/m²/year) but can also incorporate broader aspects (e.g. climate performance standards (CO_2 /m²/year, whole-life carbon and wider environmental, social and governance factors).

1.2. Differences and interplay between MEPS and minimum energy performance requirements in the EPBD

Article 7 of the EPBD requires Member States to take the necessary measures to "ensure that when buildings undergo major renovation, the energy performance of the building or the renovated part thereof is upgraded in order to meet minimum energy performance requirements". It also requires necessary measures to ensure minimum energy performance in the case of the renovation of certain building elements. Article 7 is implemented by energy codes and regulations. Codes regulating energy performance have historically been additions and expansion to earlier building health or life safety codes, or codes addressing insulation, initially developed for new buildings. These codes

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[1] BPIE et al. (2020), Lessons learned to inform integrated approaches for the renovation and modernisation of the built environment, ENER/C3/2019-468/03, December 2020.

[2] As the definition is overlapping with that of MEPS, in this Impact Assessment the reference to "Minimum mandatory requirements" or MMR which is used in the "Lessons learnt" study is substituted by MEPS.

are applied to new construction or to an existing building when some form of change to the building structure or major infrastructure takes place. The energy efficiency requirements in these codes for existing buildings can be the same as for new buildings or may be less rigorous, to accommodate practical, technical or cost constraints.

The provisions under Article 7 EPBD and MEPS have a different basis and different triggers for when they take effect, as summarised in the following table.

Table F.1: Energy codes applied to existing buildings compared with performance standards[3]

	Minimum energy performance requirements	**Minimum energy performance standards**
Basis	Codes are generally developed for new construction, though some new construction requirements are often applied to existing buildings in case of substantial renovation or alteration projects	Based on some threshold of building energy or carbon performance linked to a performance rating (either calculated or measured), or a measured energy or carbon intensity
Basic trigger for requirement	A "one-time" requirement to meet prescribed energy efficiency levels or performance when renovating, refurbishing or remodelling an existing building, generally when the level of renovation exceeds a stated portion of the building floor area or value, or some specified construction value	Meet a prescribed energy performance level by a given date, and/or on change of tenancy or ownership, often with the performance level ratcheted up over time, sending longer term signal for requirement(s) in the future

1.3.Design options for MEPS

The experience worldwide shows that there are a variety of different policy design decisions that have substantial impact on how many buildings are impacted by performance standards, and the level of savings resulting from the standards. These design criteria have guided the definition of the options on MEPS included in Chapter 5 and are illustrated in more detail in the following sections.

1.3.1 Type of standards and requirements.

An international review[4] identified the following types of MEPS, based on the type of requirement established through MEPS:

- **Prescriptive standards on specific buildings element**: prescriptive standards identify specific minimum standards such as insulation levels or appliance efficiency levels. These standards aim to improve the performance of the building, while focusing just on one of its elements.
- **Performance based renovation targets and requirements**: performance standards go beyond just individual building components and address overall building energy

[3] Elaborated from BECWG (2021)

[4]https://www.energy.gov.au/sites/default/files/BEET%2010%20Minimum%20Energy%20Standards%20for%20Rented%20Properties%20-%20An%20International%20Review.pdf

performance. This category could also include goals and milestones like the ones included in Long-Term Renovation Strategies.

- **Quality and comfort standards**: this type focuses more on setting minimum overall quality, safety (e.g. fire and anti-seismic) and comfort standards as part of a broader quality improvement policy, but always in conjunction with elements that will improve energy efficiency.

1.3.2 The metrics and performance type to be used.

A well-designed metric – tailored to the specific purpose of the MEPS – is crucial for its success. A metric serves to express the performance of a building in a specific category, for example, an energy metric in kWh/(m2.yr) or a carbon metric in CO_{2eq}/(m2.yr). In general, for the overall building sector, metrics are mainly used to evaluate the energy performance of the building, its climate impact, or indoor environmental quality.[5] For single buildings, metrics can get more specific and relate to construction materials, installations, or building elements.

Metrics could also be applied to renovations, and there are many ways in which they could be expressed. For example, in the existing Article 7 EPBD energy performance requirements are set for buildings undergoing major renovations. These requirements are set for the building as a whole or for building elements.

Some commonly used metrics refer to the energy performance of a building which is reflected in Energy Performance Certificate (EPC) class, energy consumption, GHG emissions, elements of the energy codes (e.g. U-values), etc. From the existing experiences in the EU, energy performance rating based on EPCs has been highlighted as one of the most appropriate approach to be used to define minimum performance level.

Another important metric differentiation is between asset-based ratings and measured-based ratings:

- Asset-based ratings refer to a calculated energy efficiency level, which often aggregates the designed performance of the different building components (heating system efficiency, the thermal resistance of the envelope etc.). Most EPCs are fully, or predominantly, based on asset ratings. The main strength of asset-based rating is that it allows for a more reliable comparison between buildings, as the buildings with the same components should get the same rating. The main weakness is that the calculated energy performance is usually not

[5] Fawcett & Topouzi. (2020). "Residential retrofit in the climate emergency: the role of metrics". Buildings and Cities. (Available: Online).

aligned with the actual energy performance (i.e. resulting in a potential energy performance gap), due to the calculation, installation and/or user behaviour.[6]

- Measured-based ratings[7] include metrics based on actual energy consumption, which can be done through utility bills or smart meter data. A prominent example of an operational rating is the Energy Start Score in the USA, which is based on smart meter data.

Existing MEPS have predominantly been focused on improving a building's energy performance during its use phase. There are good reasons for prioritising operational energy savings as, currently, this represents the main source of emissions in existing buildings. However, considering the whole-life carbon impact in new constructions, and in renovations of existing buildings, will help addressing and reducing the overall impact of the building sector across their life-cycle. This is addressed in the provisions for new buildings and in the national building renovation plans.

This potential could be fostered by appropriate design of MEPS, integrating whole-life carbon considerations based on reliable data, calculations and standards, which need to be further evolved and operationalised before they could be effectively used for MEPS across the EU.

As soon as lifecycle and embodied carbon data becomes more readily available, MEPS could evolve to consider whole-life carbon emissions, including emissions from manufacturing and construction through to the end of life and disposal of buildings.

1.3.3 Buildings to be targeted and their challenges.

MEPS can be designed to target specific building segments. The building's function can also be a criterion for the design of MEPS, e.g. residential or non-residential buildings. Design can be tailored to a building typology, specified to e.g. detached houses, terraced houses or apartment buildings. Another possible option is to target a specific segment of the housing market, e.g. privately owned, the rental sector or social housing, or e.g. buildings constructed before a given year. Furthermore, a common criterion used in certain MEPS scheme is a minimum building (portfolio) size in terms of floor area in square metres.

Worst performing buildings can be identified based on class of performance in EPC or looking at the age of buildings, which is often a good indicator of the average efficiency of the building.

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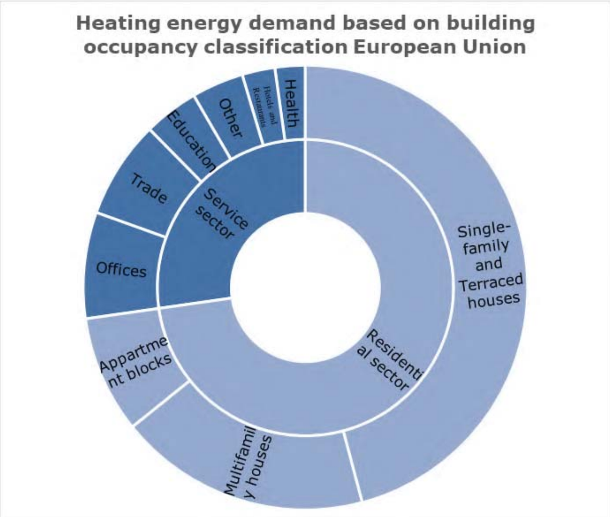
[6] IEA (2019) EBC Annex 71. Building Energy Performance Assessment Based on In-situ Measurements. (Available: Website)

[7] Also referred to as "operational rating".

Non-residential buildings (e.g. education, healthcare, hotels and restaurants, public offices, private offices, trade and wholesale) account for 24% of the total floor area.[8] To achieve a significant impact, MEPS need to target older residential buildings which have lower energy performance. Larger multi-family buildings and non-residential buildings are also relevant as target building segments.

Figure F.1 shows that the residential sector is responsible for almost 75% of the EU's building stock's heating energy demand, in which single-family and terraced houses are the most demanding.

Figure F.1: Heating energy demand - building use[9]



There are specific challenges to be addressed depending on the type of buildings subject to MEPS.

Buildings with multiple ownership

MEPS focused on triggering renovation at property transfer may not be as effective in multi-ownership buildings compared to single-ownership ones. The complex decision-making process in multi-ownership buildings may be a considerable barrier to renovations, especially medium and deep ones[10]. Mandatory implementation of renovation would demand action from homeowners associations or follow the voting or other rules established at national or local level (which need to have a clearly defined legal status and rely on agile decision procedures).

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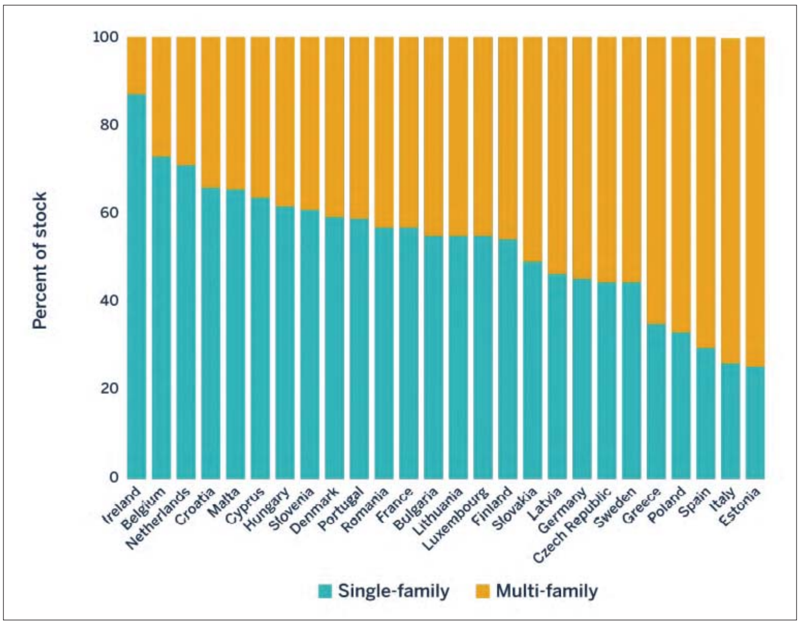
[8] Entranze Project. Policies to Enforce the Transition to Nearly Zero-Energy Buildings in the EU. European Commission - Intelligent Energy Europe programme. (Available: Website)
[9] Hotmaps database, apartment blocks are multi-family buildings with five or more dwellings.
[10] The purpose, governance and frequency of homeowner association varies across the EU and well-functioning homeowners associations is not a given. See for example: Economidou M et al (2018) Energy efficiency upgrades in multi-owner residential buildings - Review of governance and legal issues in 7 EU Member States, European Commission JRC. (Available: Online)

The presence of multi-family buildings vary significantly across countries, and while in some Member States they represents a small share of the floor area of the residential sector, in others they represent more than half.

Heritage buildings

Heritage buildings bring specific values and challenges, discussed in the European Framework for Action on Cultural Heritage.[11] The cultural and aesthetic value of these buildings can make them more challenging to renovate. For example, alterations to the interiors, facades or roofs might not be possible without negatively affecting their historical and architectural significance. Furthermore, these older buildings are often extra vulnerable to the effects of climate change.[12] As such, the applicability of MEPS to heritage buildings should be tailored at the national or local level, where policymakers have the most knowledge on the regulatory framework, local climate conditions and the cultural significance and sensitivities.

Figure F.2: Distribution of single-family and apartment buildings (residential) in the EU[13]



Source: Building Stock Observatory

Seismic Strengthening of Buildings

Seismic strengthening of vulnerable buildings is the best way to reduce existing earthquake risk. Seismic strengthening is intended to improve the safety of buildings and its occupants in case of earthquake.

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11 European Framework for Action on Cultural Heritage. (2018). European Union. (Available: Online)
12 Historic Environment Scotland. (2020). "Climate Action Plan 2020-25". (Available: Online)
13 Building Stock Observatory.

Approximately 40% of the buildings located in EU seismic regions are designed with inferior safety requirements[14]. Since we can neither predict nor stop earthquakes from happening, the non-compliance to state-of-the-art building standards in seismic prone regions, is source of concern that has to be taken into consideration when addressing renovation of old building stock.

Over time, building seismic standards have improved substantially in almost all EU Member States. Nevertheless, 80% was built before the 90's, while 40% are pre-60's and a considerable amount being even older and classified as cultural heritage. This implies that, while people safety has increased, there are still margins for improvement of the EU building stock conditions overall.

Co-investment in seismic strengthening and energy efficiency improvements offers a significant co-benefit for EU countries, especially in urban areas that comprise ageing building stock, which often has high social, financial, recreational, and cultural value.[15]

A number of Member States, e.g., Croatia, Italy, France, Romania and Slovenia, include simultaneous energy and seismic retrofit of buildings in their national Recovery and Resilience Plans.

1.3.3 Trigger points

In the lifetime of a building, certain events lend themselves well to trigger a renovation. For instance, when a house is sold this provides an opportunity to renovate at the time when the new owners structure long-term financing (mortgage) and before they move in, thereby reducing the nuisance of the construction work. Additionally, a switch of tenants or a change of function of a building (section) can function as a suitable moment to renovate with least inconvenience for the building owners and users. MEPS can use these 'trigger points' to require building owners to improve building performance. In the Flanders Energy Plan Draft, for example, non-residential building owners are required to renovate their building within five years of purchase.[16]

Also in this case, this trigger points would have different impacts across countries, depending on the dynamics of the rental or national property market. In some countries for cultural or other reasons, renting houses are much more diffused or popular than

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[14] Gkatzogias, K., Tsionis, G., Romano, E., Negro, P., Pohoryles, D., Bournas, D. and Raposo De M. Do N. E S. De Sotto Mayor, M.L., Integrated techniques for the seismic strengthening and energy efficiency of existing buildings: Pilot Project Workshop, 16–19 November 2020, Gkatzogias, K., Raposo De M. Do N. E S. De Sotto Mayor, M.L., Tsionis, G., Dimova, S. and Pinto Vieira, A. editor(s), Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-30255-1, doi:10.2760/665617, JRC124045.

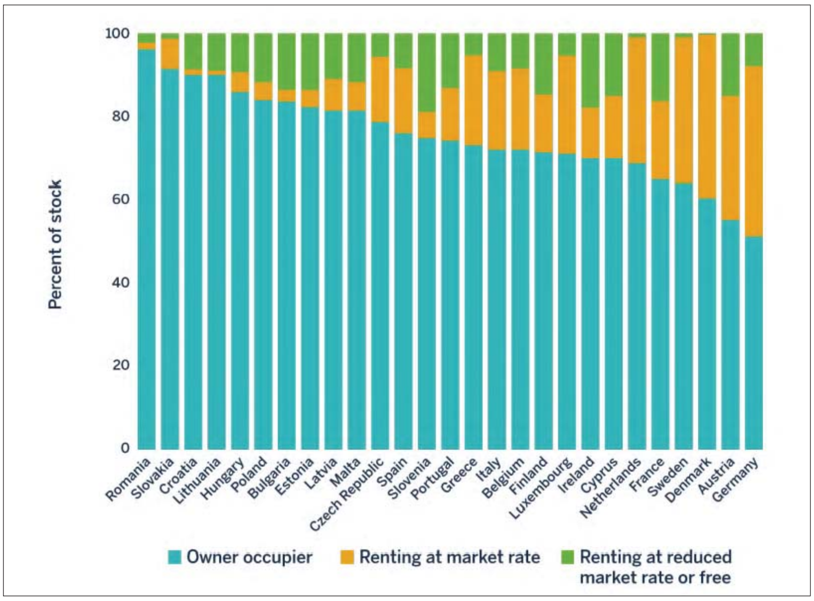
[15] The Pilot Project 'Integrated techniques for the seismic and energy retrofit of buildings' will provide evidence and guidelines for the integrated renovation of existing buildings for energy efficiency and seismic strengthening, based on the analysis of the current state of the building stock in Europe, scenarios for intervention, technologies for renovation and assessment methodologies.

[16] Flemish Energy Plan. (2018). "Ontwerp Vlaams Energieplan". Flanders Government. (Available: Website)

being owners occupiers. According to the data from the EUROSTAT EU-SILC survey, while tenants represented less than 30% in 24 MSs with very low shares in Eastern European countries, this share was close to 50% in Germany and Austria.

The research institute CE Delft indicates in a report on zero-carbon buildings that utilizing trigger points for building renovation can contribute significantly to achieving a zero-carbon building stock in 2050[17]. Moreover, research from the Energy Saving Trust indicates that the majority of British building owners are willing to invest additional funds in energy efficiency measures during already planned renovation measures[18]. This illustrates the relevance of harnessing the power of trigger points to improve building performance, and the potential to tap into by integrating trigger points in the MEPS design.

Figure F.3: Distribution of population by tenure in the EU (2018)[19]



Source: Eurostat/SILC

The Figure below illustrates that the required renovation rate and depth can be reached with different means. ‘If the energy demand of dwellings can be reduced by an average of 60% when changing owners (representing 1.7% of the dwellings per year), renovation

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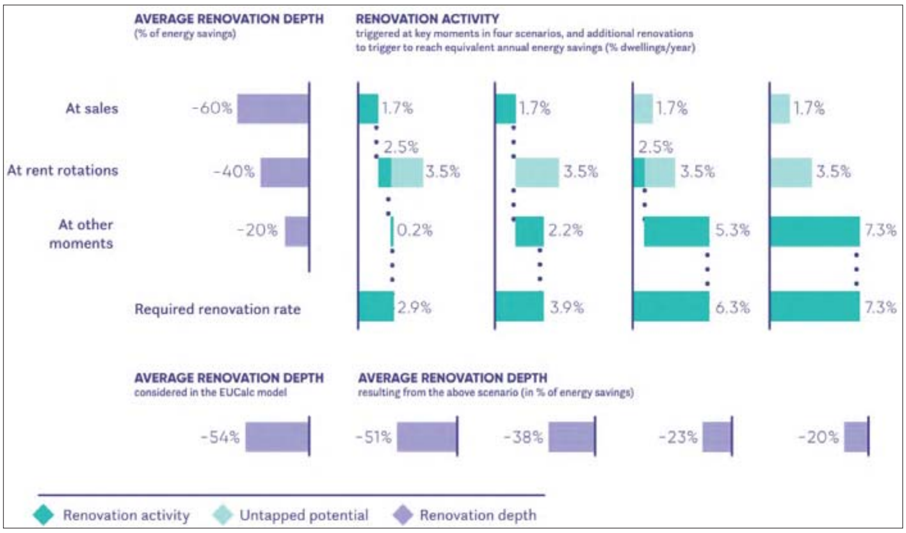
[17] European Climate Foundation. (2020). “Zero Carbon Buildings 2050”. Modelling by Climact based on EU Calc data. (Available: Online)

[18] Energy Saving Trust. (2011). “A convenient truth – Promoting energy efficiency in the home”. (Available: Online)

[19] EUROSTAT EU-SILC.

associated with other key moments would not need to happen at as high a renovation depth’[20].

Figure F.4: Different renovation rates and depths at key moments reach different average energy savings in four scenarios[21]



1.3.4 Enforcement and flexibility

Measures to facilitate implementation and enforcement are also important to ensure MEPS effectiveness, providing the real estate sector adequate time to integrate these measures into the building’s economic lifecycle, especially for any measures that have long payback period and for buildings with low-income tenants.

Good monitoring simultaneously facilitates compliance checks by providing regulators with insight into the energy performance of existing buildings. Sufficient administrative capacity is a pre-requisite to achieve qualitative monitoring and effective compliance.

In many existing cases, compliance is stimulated and enforced [carrot and stick] with on the one hand financial subsidies and grants, combined with financial penalties in case of non-compliance. The fine can increase depending on the duration of non-compliance and can be embedded in a bonus-malus scheme. These funds can be used for grants

[20] European Climate Foundation. (2020). “Zero Carbon Buildings 2050”. Modelling by Climact based on EU Calc data. (Available: Online)

[21] The renovation depth is associated with three key moments (left-hand purple bars) and four scenarios (right-hand green bars) illustrate the required increase in the renovation rate resulting from lowered renovation depth following the untapped potential of key moments. The first scenario captures the full potential of key moments, leading to a 2.9%/year renovation rate with 51% average energy savings. Staged renovations outside of key moments would require a 7.3%/year renovation rate to provide similar energy savings. The bottom purple bars provide the average renovation depth corresponding to each scenario. Source: Kruit et al. (2020) Bringing buildings on track to reach zero-carbon by 2050

stimulating building owners to reach the 2050 target (i.e. deep renovation) as early as possible. Financial support programmes are often introduced alongside MEPS to improve compliance and foster early action.

Furthermore, most jurisdictions have set up educational programmes for technical assistance. A barrier to enforcement in England and Wales was the lack of administrative capacity in the municipalities to carry out the enforcement and follow-up work. This illustrates the importance of well-equipped and trained local administrations and practical design for the effectiveness of MEPS.

MEPS could also be based on an enforcement calendar, which sets out a timeline for the affected buildings, defining when they need to comply with the specific requirements. Most commonly, and as implemented in the MEPS in the UK, MEPS increases the level of ambition over time, guiding the market towards a long-term target. In each enforcement step certain requirements are enacted, e.g. an EPC rating, specified carbon emission level, or something else.

Enforcement calendar schemes can be applied to all building segments, types and ownership structures. For non-residential and larger building owners, the enforcement calendar can be applied to their portfolio of buildings (i.e. assets). The owner/investor can then plan their portfolio investments in line with future thresholds, which incentivises investments in high-performing buildings. Certain building/ownership types, such as public or non-residential buildings, could be mandated to meet the requirement a couple of years in advance and thus lead by example.

1.4.Stakeholder's views on MEPS

The views of stakeholders on MEPS were collected on different occasions, and supported the indication of MEPS as key regulatory instruments to implement the goals of the Renovation Wave, and its corresponding mandate to review the EPBD to include such an instrument. This section recalls and collects the view of stakeholders prior to the specific consultation conducted in preparation of the revision of the EPBD, which is instead included in Annex B. Such views are important because preferences have been expressed also in relation to the design of MEPS, which have been taken into account in the identification of options for MEPS in Chapter 5 of this Impact Assessment and in the identification of the preferred option.

1.4.1 Stakeholder's views on MEPS in the "Lessons learnt" study.

In the context of the study on "Lessons learnt", stakeholders were consulted to gather their views on minimum energy performance standards[22]. Around 80% of stakeholders

[22] Stakeholders have been involved in two ways in this study: (1) 113 stakeholders answered an online survey and (2) over 100 stakeholders participated in an online workshop. The stakeholders represent different sectors and professions, including building owner representatives, tenant organisations, installation manufacturers, construction sector, financial sector, public administration, (energy) service providers, civil society, and research institutes.

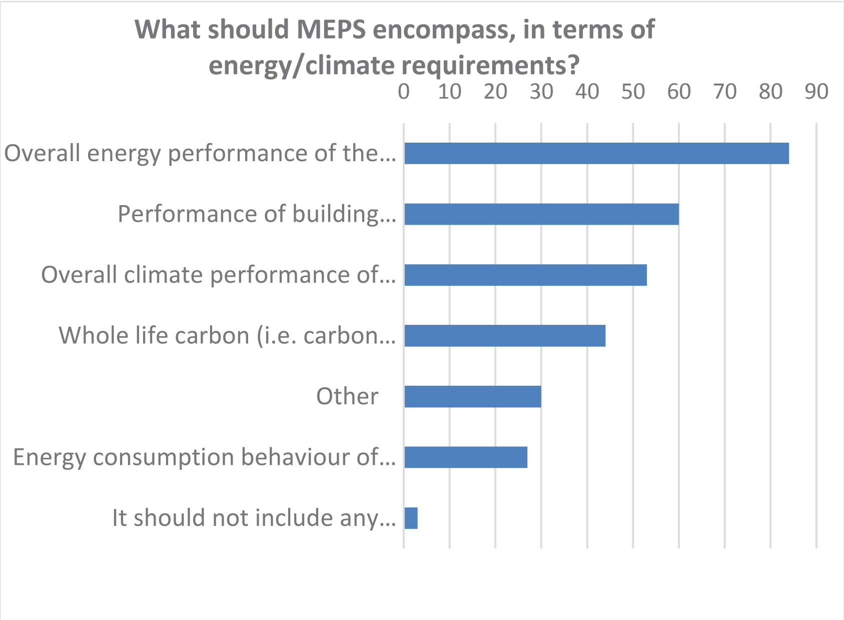
consulted thought that MEPS are a necessary policy for the EU to decarbonise the building stock by 2050. The same share of respondents also argues that the EU should actively support and encourage MEPS.

Figure F.5 displays stakeholders' preferences for different MEPS types; most respondents think more than one type of MEPS could be successful. The large majority of stakeholders consulted via the survey - three-quarters (74%, or 84 out of 113 survey respondents) - think that the MEPS should focus on the overall energy performance of the building. Over half (53%) think MEPS could be linked to certain building components, while almost 50% say it should be linked to the building's overall climate performance. Only a quarter (24%) say the MEPS should be linked to the occupants' energy behaviour, while less than 3% think the MEPS should not encompass energy or climate requirements.

During the stakeholder workshop, support was expressed for carbon efficiency (i.e. maximum GHG/m^2/year) as an MEPS parameter because this provides most certainty for the long term and gives the building owner more freedom to decide how the requirement will be met.

Some stakeholders stressed that incorporating indoor environmental quality, embodied carbon and/or accessibility for disabled people in MEPS should be considered. In contrast, other stakeholders argued that MEPS should only focus on energy performance parameters, to be kept simple and effective.

Figure F.5: Survey question – Stakeholders' preferences for different types of MEPS (several votes possible)



The views among stakeholders were diverse when it comes to central design options, such as target groups, trigger points and when the requirement should apply. It was reiterated that these aspects ought to be defined at the national and/or regional level, which explains some of the divergent views.

The stakeholders generally think that MEPS can best be applied to the worst-performing buildings, excluding heritage buildings. This will achieve the highest impact in the short term. Additionally, the building owners' ability to comply with the requirement should be considered. The most widespread view (57% of respondents) is that MEPS should encompass all building typologies. This view was followed by a focus on larger and more polluting buildings, such as public buildings (41%), multi-family buildings (31%), commercial buildings (30%), all non-residential buildings (28%) and larger buildings and portfolios of building assets (27%). Less popular are low-income households (10%) and social housing (20%). See all answers in Figure 45.

One popular opinion is that MEPS could initially best be targeted at public and/or larger commercial buildings. This might, according to the stakeholders, kick-start local renovation markets and improve renovation skills amongst construction workers.

Figure F.6: Survey question – building and ownership types to be targeted by MEPS (several votes were possible)

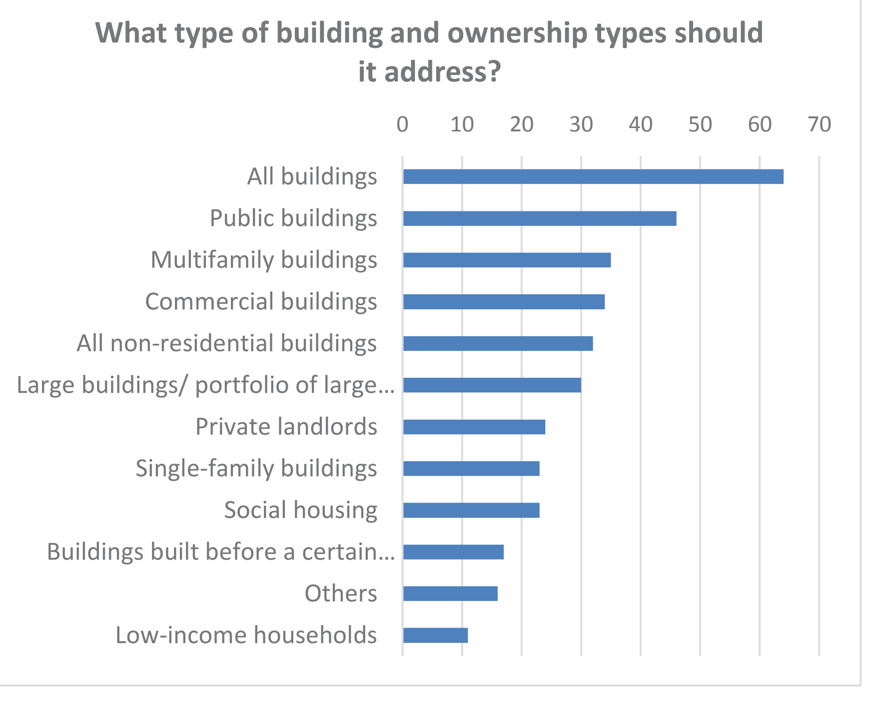


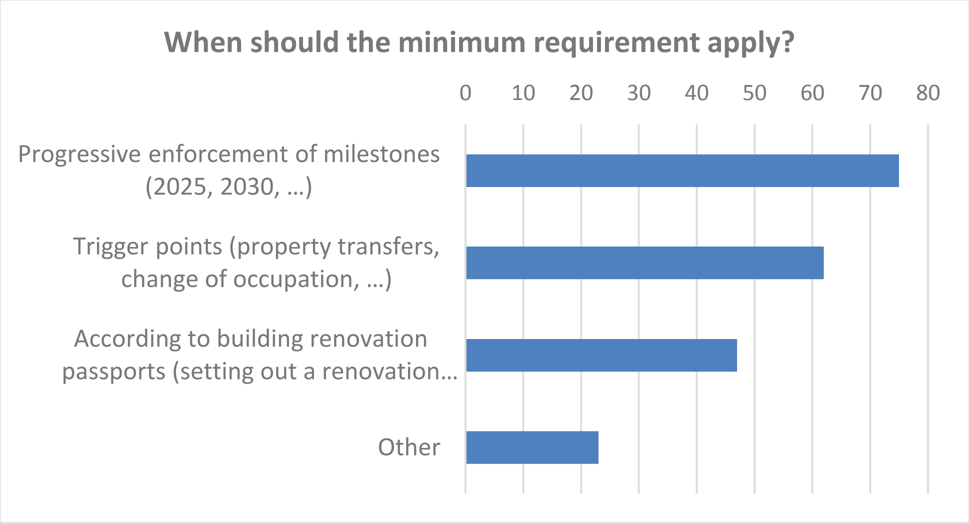
Figure F.6 shows that many stakeholders want the MEPS to include both progressive enforcement of milestones and various trigger points, something reaffirmed in the workshop discussion. In the multiple-choice question on when the MEPS should come into effect, most participants say MEPS enforcement based on progressive milestones (66%) and trigger points (55%) are the best solutions.

Most stakeholders argue that MEPS should support long-term objectives and that the deadlines for the requirements should be planned and communicated well in advance.

This gives property owners and the market time to adapt and take actions. The enabling framework could also be coupled to long-term targets and stimulate quick action. Financial measures could be designed to reward early action with high support and be reduced closer to the deadline.

The argument for linking MEPS to a building renovation passport (which is supported by 42% of the respondents) is to avoid technical and economic lock-in effects. Other participants perceived the choice between staged and one-step deep renovation as too simplistic and called for an open mindset to find a balanced solution.

Figure F.7: Survey question – When should the requirement apply? (several votes were possible)



Stakeholders view the EPC framework as a natural way of implementing and enforcing MEPS by the EU. It was, however, also stressed that the reliability of EPCs and their (lack of) comparability across the EU remains a barrier. Concerning EPCs, it was also concluded that they could be expanded to include other non-energy parameters like indoor environmental quality, which could then be taken into account by future MEPS.

The next figure displays what the stakeholders view as the most suitable trigger points for MEPS. Some 86% (97 out of 113 respondents) say that major renovation or building-related construction work is the most suitable trigger point, which partially links to what Article 7 of the EPBD provides[23]. Most respondents think ‘property transfer’ (62%) and ‘change of use’ (50%) are good trigger points for MEPS.

There is almost a consensus among stakeholders on the view that MEPS cannot function without a supportive policy framework. Participants mentioned financial support

[23] Article 7 of the EPBD states that "Member States shall take the necessary measures to ensure that when buildings undergo major renovation, the energy performance of the building or the renovated part thereof is upgraded in order to meet minimum energy performance requirements set in accordance with Article 4 in so far as this is technically, functionally and economically feasible."

schemes (green loans and grants), awareness and communication campaigns, long-term planning tools, training of experts as well as a compliance and enforcement strategy, as essential enabling measures. The survey showed that most stakeholders view all enabling measures to be, at least, moderately important. Financial support was seen as the most important measure (85% say it is ‘very important’ or ‘important’), followed by information measures (73%) and long-term planning tools (80%).

It was also stressed that the EU must take further actions to improve the trustworthiness of EPCs and make sure data supporting MEPS is reliable and comparable. Stakeholders suggested that the EU can play an important role in harmonising data collection and facilitating the comparison of EPCs within the EU. Concerning the supply of construction materials and building installations, MEPS could play a role in ensuring that, even if MEPS are defined on a local scale, it is still part of a wider and comparable European framework.

In addition, continuing the work on raising awareness on building performance, for example through one-stop shops, was frequently referred to as part of the solution.

Some stakeholders warn of the additional financial burden MEPS can impose for some building owners and tenants. This is in general seen as the most important aspect that should be addressed and solved. Financial support is seen as the most suitable solution to this barrier.

1.4.2 Stakeholder’s views on MEPS in the consultation for the revision of the EPBD.

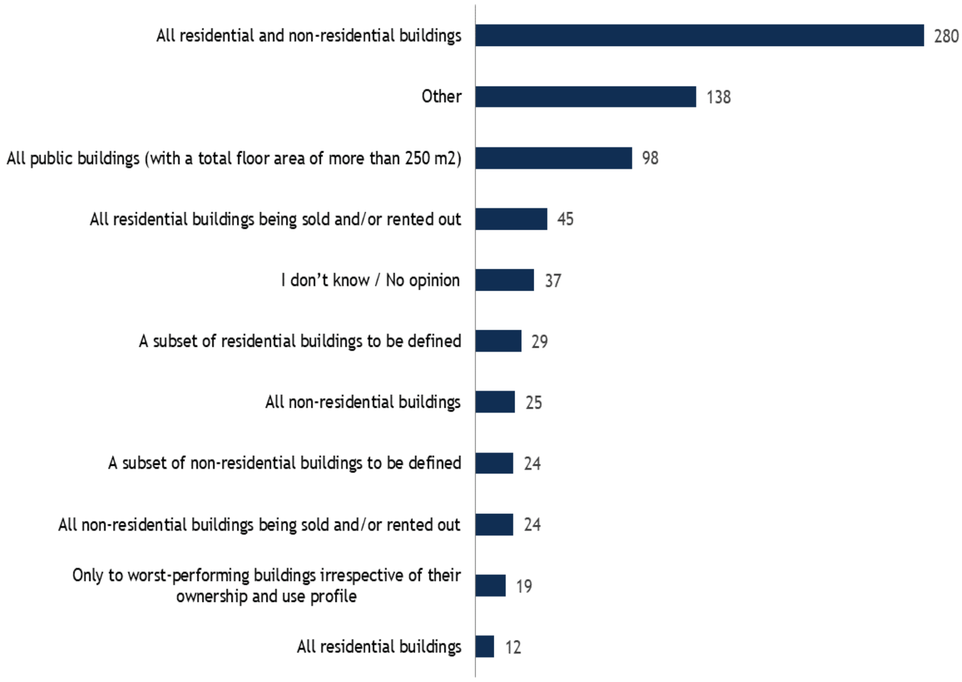
The vast majority of stakeholders consulted agreed that mandatory minimum energy performance standards (MEPS) should be introduced in the EPBD. As regards the types and ambition of the standards to be set, the overall energy efficiency, linked to Energy Performance Certificates (EPCs) received high support. It was also indicated that MEPS should cover both residential and non-residential buildings. MEPS should be implemented in a staged approach and linked to specific moments of a building life-cycle. The most important element to guarantee a successful roll-out of MEPS is the availability of financial support to building owners.

In the public consultation, 17% of respondents disagreed to the introduction of MEPS, and the explanation provided referred to the differences of the building stock across MSs making a EU-wide MEPS challenging (e.g. different climate conditions, geography, culture, renovation needs). Local MEPS were suggested as an alternative. Some respondents also referred to the fact that MEPS already exist in some Member States which could conflict with a EU approach and indicative guidance instead of mandatory MEPS would be preferable. It was also indicated that measures should be voluntary to ensure affordability for future generations.

MEPS should not be a standalone measure and must be accompanied by EPCs and BRPs to support owners in long-term planning. There should also be a focus on worst performing buildings (in the short term) and framework should promote deep renovation to avoid lock-in effects. Stakeholders also suggested:

- A detailed planning describing the requirements, which benefits for their application and the timeframe should be developed and revised in a transparent way;
- Minimum of energy efficiency should be fixed (under certain conditions) and take into account the technological evolution of system and materials;
- MEPS should be applied for green public procurement/public buildings;
- MEPS should be phased in different building types at different points in time; and
- MEPS design should be flexible to national and local conditions/priorities.

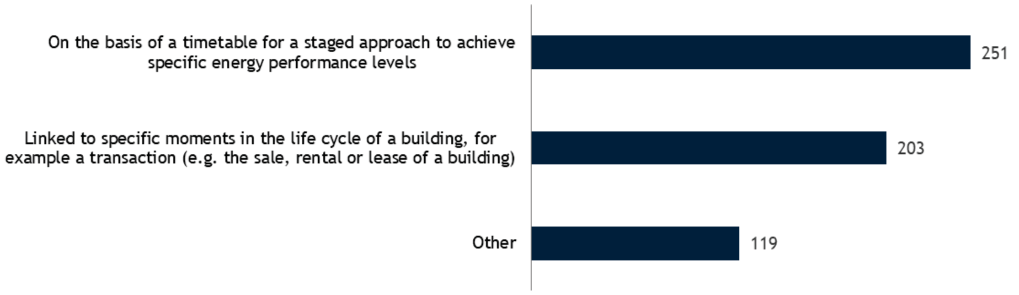
Figure F.7: In your view, for which category of buildings should mandatory minimum energy performance standards be applied? (n=X)



As regards the type of buildings to be covered, the majority of the public consultation respondents favoured a wide approach covering all buildings. Respondents were quite split on the questions regarding how to set MEPS (figure below), for which support was received both on the basis of a staged approach based on a clear timeline and linked to specific moments in the buildings lifecycle. Many stakeholders referenced the need to implement the two response choices from the public questionnaire (figure below), staged approach and links to trigger points in building lifecycle, for the introduction of MEPS. Particularly, it is suggested that a hybrid approach should be taken, which entails a timetable for a staged approach and more accelerated when transactions are made.

Stakeholders also call for a clear timeline and targets with compliance deadline based on long-term goals, which will incentivise gradual acceleration in energy renovations. Some stakeholders further explained why trigger points should be used, namely because they limit the risk of missing opportunities to renovate and avoid lock-in effects. Some stakeholders also indicated specific trigger points, such as change of owner or use of buildings and the building passing a certain age, such as 50 year. Some stakeholders suggested that rental should not be a trigger point.

Figure F.8: Suggestions for the introduction of mandatory minimum energy performance standards (n=391, 573 responses)



When identifying the most important factors to guarantee a successful roll-out of MEPS, stakeholders mentioned the elements in the following order: availability of financial support to building owners, the presence of a stable legal framework, the availability of adequate workforce capacity, the correct identification of the worst-performing buildings, and the availability of emerging technologies.

1.5. Overview of MEPS experiences across the EU and beyond

Europe

In Europe, some countries have implemented MEPS, examples of such cases are France, the Netherlands, Belgium. The metric used for the standards in many cases relates to a minimum EPC rating, a theoretical calculation known as 'asset rating'. In certain regions, e.g. Brussels and France, examples exist that focus on the measured energy, known as 'operational rating'. The building segments targeted by these MEPS regimes are diverse, including both residential and non-residential buildings. Compliance is based on compliance cycles, trigger points like sale or renovation, and, in the case of Brussels, building renovation passports.

Table F.2: Overview of MEPS cases analysed in Europe

Name/description of requirement	Location	Building type	Metric	Effective/ Enforced	Compliance category

Mandatory progressive implementation of a renovation roadmap	Brussels, Belgium	Non-residential	Asset rating	2030	Building renovation passport
Mandatory energy consumption reductions (PLAGE)	Brussels, Belgium	Non-residential	Operational rating	2019	Enforcement calendar
Minimum energy performance standard for all tertiary buildings[24]	Flanders, Belgium	Non-residential	Asset rating*	2030	Change of owner
Minimum energy performance standard for residential buildings	Flanders, Belgium	Residential	Asset rating	2021	Change of owner
Minimum quality standards for basic comfort, safety and health	Flanders, Belgium	Residential	Asset rating	2021	Complaints by tenants
Travaux embarqués (embedded work)	France	All	n/a	2017	Implementation of other works
Minimum energy efficiency standard	France	Residential	Asset rating	2025	Enforcement calendar/ change in tenancy
Mandatory final energy consumption reduction targets for tertiary buildings	France	Non-residential	Operational rating	2030	Enforcement calendar
Minimum Energy Efficiency Standard	England and Wales	Residential	Asset rating	2018	Change in tenancy/Enforcement calendar
Minimum Energy Efficiency Standard	Scotland	Residential	Asset rating	2020	Change in tenancy/Enforcement calendar
Minimum standard for all office buildings	Netherlands	Non-residential	Asset rating	2023	Enforcement calendar
Renewable heating and efficiency obligation	Germany, Baden Württemberg	Residential and most non-residential	Asset rating	2008 (with updates 2015)	Trigger point (heating system)
Minimum energy performance standard for public buildings	Greece	Public buildings	Asset rating	2015	Change in tenancy

Mandatory progressive implementation of a building renovation passport

[24] All non-residential and non-industrial buildings.

Brussels, Belgium

The scheme is being developed to improve the energy efficiency of the capital's non-residential buildings and meet international climate goals, especially the 2030 climate objectives of the EU. The vision has been translated into concrete objectives in a strategy document, which was adopted by the Brussels government in 2016 and aims to reduce GHG emissions by 30% by 2025.[25] The Brussels LTRS also includes references to renovation requirements from 2030 onwards based on specified time intervals linked to a building renovation passport (BRP).[26]

Status: Planned.

Legal provision

The scheme aims to reduce the primary energy consumption (kWh/m²/year) of the non-residential building stock. Targeted building owners must propose a three-year action plan to reduce primary energy consumption. The mandated renovations are based on cost-effective measures defined by the local administration, which the building owner refers to in the action plan. The energy reduction in the plan is mandatory and applies to the total building stock owned. The owners decide which measures to apply.

The scheme operates in five-year cycles. The first year is used to formulate the plan, while the subsequent four years are used to execute the plan. The plan is based on 'Energy Performance Certificates 3.0'. These are based on, amongst other factors, thermal insulation, airtightness and heating installations, and thus an asset rating.

Building typology

The programme applies to:

- Properties of federal, regional and municipal public authorities with more than 250m² floor space.
- Other publicly owned buildings with floor space larger than 50,000m².
- Large privately owned properties with more than 100,000m² floor space.

Compliance mechanisms

At the end of every five-year cycle, the execution of the plans is verified by the Brussels Environment Office. If the procedures are deemed non-compliant, sanctions are applicable including administrative fines. The fines amount to €0.06 per exceeding kWh if no valid reason has been provided.

Key success factors

[25] Second National Energy Efficiency Action Plan Belgium (2011). Belgium.
[26] Strategy to reduce environmental impact of buildings Brussels (2020). Mandatory renovations at 5-year intervals to achieve decarbonisation in 2050. LTRS, p42.

- Proper training for inspectors.
- Cost-effective measures are mandatory and will quickly be implemented. This is good for efficiency but discourages the uptake of less cost-effective measures in investment packages.
- A regulation or scheme fostering the re-investment of the cost-savings from lower primary energy consumption in other energy efficiency measures would enhance the effectiveness but is currently absent.

Minimum energy performance standard for all tertiary buildings

Flanders, Belgium

The 2019 Flemish coalition agreement set specific energy efficiency targets as part of Flanders' 2050 goals for the building stock. Within the Draft Flemish Energy plan 2021-2030, the Flemish authorities specify policies to achieve these targets, including energy efficiency measures for the tertiary sector (all non-residential and non-industrial buildings).[27] The rationale behind energy efficiency and more responsible energy usage is to reach European climate targets and reduce energy costs. To achieve this vision, inefficient large non-residential buildings are required to get energy labels and need to be renovated after they are sold.

Status: Planned.

Legal provision

As of 2021, all non-residential buildings are required to undergo a thorough energy renovation within five years after purchase to reduce their climate footprint.[14] From 2025 onwards, all Flemish large non-residential buildings are obliged to have an EPC. After 2030, they also need to reach a minimum energy label (yet to be defined). Public buildings (owned by the government) will need to comply with these measures two years in advance of private building owners.

Building typology

Non-residential buildings (tertiary sector)

Compliance mechanisms

The penalty will probably be monetary fines, but it is yet to be defined.

Key success factors

[27] Draft Flemish Energy Plan. (2018). Flemish Government.

- The Flanders Energy Agency indicates that this policy is aligned with the long-term goals of carbon neutrality for non-residential buildings.
- The buildings are assessed on actual energy consumption rather than theoretical consumption.
- Transition measures could be considered in the form of no-regret or renewable energy production. Additionally, a requirement for energy audits including obliged implementation of cost-effective measures (like in Brussels) or the adoption of energy management systems could contribute to realising the potential of this policy.

Minimum Energy Efficiency Standard

England and Wales

The Minimum Energy Efficiency Standard (MEES)[28] was introduced in March 2015 by the Energy Efficiency Regulations.[29] The MEES originates from the Energy Act of 2011, which was a package of energy efficiency policies including the now defunded Green Deal. The MEES has been designed to contribute to the legislative targets of reducing CO_2 emissions for all buildings to around zero by 2050.

The MEES is linked to the EPC framework and stipulates that a dwelling cannot be let if it does not comply with EPC rating E. The EPC rating (‘SAP rating‘), which is the infrastructure used to check compliance, gives a score from 1-100 based on the estimated cost to heat and light the building compared to other buildings of the same size. One of the main reasons for its implementation was to circumvent the split-incentive dilemma, where the landlords are responsible for the building, yet the tenants pay the utility bills.

Status: Ongoing.

Legal provision

From 1 April 2018, the MEES requires private landlords of homes rated at EPC ratings F or G to improve their property to E before issuing a new tenancy, unless they obtain an exemption. From April 2020 the MEES was extended to include existing tenancies (as long as the property has an EPC). Landlords are never required to spend more than £3,500 on energy efficiency improvements (cost cap on investment).

Building typology

Privately rented properties. Around 7% of the targeted building stock has an EPC rating worse than label E.

[28] Domestic Minimum Energy Efficiency Standard Guidance Site (2017). United Kingdom
[29] The Energy Efficiency (Private Rented Property)(England and Wales) Regulations (2015).

Compliance mechanisms

If a landlord does not provide the requested information or lets a substandard property, they get a monetary fine. The fine ranges between £2000 and £5000 (≈ €2035 and €5585).

Key success factors

- A mature and reliable EPC framework. In the UK and several other countries, there is a lack of confidence in the quality and reliability of EPCs.
- An EPC database which enables the implementing public authorities to check compliance.
- The implementing body must have resources to uphold and enforce the legislation.
- Avoid too many exemptions to the regulations. In the UK, 'the high-cost exemption criteria are a major reason for not putting in much effort to enforce the MEES to date'.[30]

Minimum standard for all office buildings

The Netherlands

The parties to the Energy Agreement, including the government, aim for an energy-neutral built environment in 2050, with as an intermediate step at least an average level of the (current) label A for all buildings in 2030. The 2018 amendment of the Dutch Building Decree to require that office buildings have an Energy Efficiency Index of at least 1.3 (equivalent to a 'C' EPC rating) by 1 January 2023 is part of a set of measures to achieve these targets[31].

The Dutch coalition agreement of 2017 also set forward a target of a 49% reduction in CO_2 emissions by 2030 compared to 1990 levels, which for non-residential construction (including office buildings) amounts to 3 MT CO_2 reduction. This target has also been incorporated in the Climate Agreement, which includes the ongoing commitments of the Energy Agreement as well. The label C obligation for offices is therefore also the first step to meet this CO_2 target. A tighter target of an 'A' label by 2030 was considered but not introduced. However, the 'C' requirement by 2023 is expected to be tightened to a higher level in future. In response, commercial financial institutions (ING, ABN) have indicated they will stop financing office buildings that do not meet the standard. This illustrates the effectiveness of MEPS as policy instruments.

[30] RSM. (2019). "Enforcing the Enhancement of Energy Efficiency Regulations in the English Private Rented Sector". RSM Consulting.
[31] Climate Agreement. (2019). The Netherlands

Legal provision

From 1 January 2023, all office buildings are required to have an Energy Efficiency Index of at least 1.3 (equivalent to a 'C' EPC rating)[32]. As the minimum standard applies to the use of the office building, the duty to comply can be with either the tenant or the building owner.

Building typology

Existing office buildings, with a few exceptions[33], such as office buildings with a total surface area of 100m^2 or less, buildings in which less than 50% of floor area is used for offices, and national, municipal or provincial historic buildings (except protected townscapes and villages). Out of 62,000 offices falling within the scope of this obligation, 56% do not yet have an EPC (no label registered). Of those that do have an EPC, around one-quarter (7,000) has a label of D–G, and about 20,000 have an A-C label. Since the beginning of 2016, the proportion of offices subject to the obligation with a green label (A-C) has increased by an average of 8 percentage points each year.

Compliance mechanisms

Failure to comply will be addressed through administrative enforcement measures, such as periodic penalty payments, a fine and, ultimately, the closure of the office building. The standard is generally enforced by the municipality in which the building is located, but it can also be delegated to another nominated 'competent authority.'

Key success factors

- Enabling framework: (1) online tool providing information on investment costs, energy cost savings and payback time; (2) government-approved energy advisors; (3) grant for the cost of the advice if measures are taken following that advice (in addition to existing financing schemes).

Mandatory final energy consumption reduction targets for tertiary buildings- France

The French Energy - Climate law adopted in 2019 sets ambitious targets for French climate and energy policy. The text includes the objective of carbon neutrality in 2050 to respond to the climate emergency and the Paris Agreement.

[32] Bouwbesluit (Building Code) (2012). The Netherlands
[33] Explanatory note Bouwbesluit. (2012). The Netherlands

The Tertiary Decree entered into force in October 2019 and specified the implementation of the article 175 of the “loi Elan”. It mandates an energy consumption reduction of tertiary buildings.[34]

Status: Ongoing.

Legal provision

The decree proposes two methods to achieve the target:

- The buildings (i.e. tertiary sector) must reduce their energy consumption (kWh/m²/year) compared to the reference year (which is a year between 2010 and 2020, chosen by the building manager), achieving at least[35] 40% reduction in 2030, 50% reduction in 2040 and 60% reduction in 2050.
- Or they shall achieve a threshold energy consumption per decade, defined according to the category of the building.

The building managers need to provide, via a digital platform, yearly information on the tertiary activity for which the building is used and its area in m². This information must then be published by the building owner and made available to the general public.

This decree applies to both landlords and tenants (the responsibility of each is decided in the rental contract).

The available action levers are: energy performance of buildings, installation of efficient equipment & devices for the control and active management of these, performing methods to operate the equipment, adaptation of buildings for energy-efficient use, occupant behavior, etc.

Building typology

All non-residential buildings (with a tertiary use area ≥ 1,000 m²)

Few exemptions:

- Buildings with temporary construction permits
- Buildings used for religious activity
- Certain public buildings, including buildings of defence, civil security, or national security

Compliance mechanisms

Non-compliance with this decree will be punished by:

- The publication, on a public website, of the non-compliance of the company

[34] Decree 2019-771. (2019) Decree on the reduction of energy consumption of tertiary buildings.
[35] Information website about the Décret Tertiare. (2019) Citron.

- Fine of €1,500 for a physical person
- Fine of €7,500 for legal entities.

Key success factors

- Public communication on (non)compliance.
- Obligation can be transferred to the tenant.
- Platform: needs to be clear and easy to use for building managers.
- Monitoring of the building managers' compliance with the decree (there is a need for a strong incentive and controls so that they all put their real consumption on the platform every year).

Minimum Energy Efficiency Standard for residential buildings - France

The "Climate and Resilience law[36]" resulting from the work of a Citizen's Convention for the Climate establishes a ban on the worst-performing buildings (EPC G, F and E) to reduce the emissions of the built environment.

Legal provision

Rent freeze for the worst performing buildings (art 159):
From 2022, owners of 'energy sieves' will have to carry out energy renovations if they wish to increase the rent of their housing. This is an important first signal before the entry into force of the rental bans on the most energy-consuming homes.

Prohibition on renting out poorly insulated housing: EPC G from 2025, F in 2028 and E in 2034:
From 2025, it will be prohibited to rent the worst performing buildings (EPC G), and from 2028 for buildings with EPC F. From 2034, housing with EPC E will be banned for renting.

The tenant can require the owner to carry out work and several information, incentive and control mechanisms will reinforce this right for the tenant.

All households, in particular those with the lowest incomes, will have access to a financing mechanism to pay the remainder of their renovation work. In particular, this could take the form of loans guaranteed by the state.

Building typology

The obligation applies to all residential buildings.

[36] https://www.ecologie.gouv.fr/loi-climat-resilience

Compliance mechanism

The “Climate and Resilience” law updates the concept of decent housing, which will be defined by reference to the energy class mentioned in the EPC. Rental offers must mention the energy class of the property. Non-compliance with the inclusion of correct information can result in financial penalties ranging from a maximum of €3000 (private person) to €15,000 for legal entities. In addition, the judge may order the necessary work to be carried out.

Key success factors

- Phasing out the worst-performing buildings based on energy performance.
- Building owners get sufficient time to prepare the renovation.
- The ‘Troisième ligne de quittance’[37] allows landlords to (partially) share the financial burden of energy-saving measures with tenants.
- The energy performance in the EPC of the building must be included in rental advertisements after 2022.

United States of America

In the USA policymakers recognise the need for more ambitious policies to stimulate energy efficiency in the built environment.[38] MEPS are seen as an effective approach to achieve climate targets. The development and implementation of MEPS in the USA is just beginning. Different types of MEPS in terms of metrics, building segments targeted and compliance are implemented and tested in various jurisdictions of the USA. An overview of different types of compliance is presented in Figure F.3.

Recurring metrics for MEPS are energy use intensity (EUI), sometimes related to the Energy Star Score, and carbon intensity. The first generation of MEPS implemented in the USA suggests that operational rating is more suited for large (commercial) buildings whereas asset rating is more suited for smaller or single-family residential buildings. In certain jurisdictions, only audit obligations and requirements for cost-effective renovation measures exist, rather than whole-building MEPS. The building segments most often targeted by MEPS in the USA are commercial and multi-family buildings. In contrast to Europe and Canada, single-family houses are often not targeted in the USA, except in Boulder, Colorado.[26] Compliance with MEPS is mostly based on compliance

[37] Decree 2009-1438. (2009). Decree related to tenant contribution to energy saving work. France
[38] Nadel, S & Hinge A (2020) Mandatory Building Performance Standards: A Key Policy for Achieving Climate Goals. ACEEE (Available: Online)

cycles and in some cases pegged to trigger points like sale or major renovation. Some in-depth examples are presented below in table F.3.

Table F.3: Overview of MEPS analysed in the USA

Name/description of requirement	Location	Building type	Effective	Compliance category
New York Building Emissions Law (Local Law 97 of 2019)	New York City	Larger buildings (>2300 m²)	2024	Enforcement calendar (compliance cycle of 5 years)
Building performance goals	Reno, Nevada	Residential and non-residential buildings (>2700 m²)	2026*	Enforcement calendar (compliance cycle of 7 years)
Building Energy Performance Standards	Washington DC	Larger buildings (> 4600 m²)	2026	Enforcement calendar (compliance cycle of 5 years)
Clean Buildings for Washington Act	Washington state	Larger buildings (> 4600 m²)	2026	Enforcement calendar (compliance cycle of 5 years)
Boulder SmartRegs program (2010)	City of Boulder	Residential buildings in the rental market	2019	Enforcement calendar (compliance cycle of 4 years)
Building Energy Performance Standard bill	St Louis, Missouri	Residential and non-residential large buildings (>4600 m²)	2019-2025*	Enforcement calendar (compliance cycle of 4-6 years)
Building Tune-up Ordinance	Municipality of Seattle	Non-residential buildings	2018-2021*	Enforcement calendar (compliance cycle of 5 years)
Mandatory seismic retrofit program	Los Angeles City	Seismically vulnerable buildings (soft-story buildings)	2016-2017*	N/a
Building Energy Saving Ordinance	Municipality of Berke	Small buildings at trigger point (<2300 m²)	2019-2022*	Enforcement calendar (complian

	ley	Large buildings (>2300 m²) compliance cycle		ce cycle of 5-10 years) + trigger point (sale)
Existing Commercial Buildings Energy Performance Ordinance	Municipality of San Francisco	Non-residential buildings (>900 m²) All buildings (>4600m²)	2020	Enforcement calendar (Compliance cycle of 5 years) + trigger point (sale)
Existing Buildings Energy and Water Efficiency Program	Municipality of Los Angeles	Larger buildings (>1850 m²)	2019	Enforcement calendar (compliance cycle of 5 years)
Energy Conservation Audit and Disclosure (ECAD) Ordinance	City of Austin	All buildings	2008	A trigger point (sale)
ECAD for residential Homes: Information for Home Sellers, Buyers and Real Estate Professionals.	Austin	Multi-family buildings	2008	If EUI is more than 150% of the average
New York Sustainable Roof Laws (Local Law 94 of 2019)	New York City	Residential and non-residential large buildings (>2300m²)	2019	A trigger point (major renovation)
Boulder Building Performance Ordinance	City of Boulder	Non-residential buildings	2020-2027*	Enforcement calendar (compliance cycle of 10 years)

*Depending on the building segment/size, starting with public and large buildings

**Energy use intensity

New York Building Emissions Law (Local Law 97 of 2019)

New York City, USA

The law was developed to reduce the adverse impact of climate change and limit GHG emissions. The New York City Council has proposed the Climate Mobilization Act, which aims to reduce the GHG emissions of buildings by 40% in 2030 compared to 2005 levels, and by 80% in 2050.

Legal provision

Local Law No. 97[39] provides a straightforward limit on the amount of GHG a building can emit. It mandates that covered buildings 25,000 square feet (2322m^2) and larger cannot emit GHGs at levels higher than the limits set by the law. It defines mandatory emission intensity limits (metric tons of CO_2/m^2) for different Building Code occupancy groups, based on use and type of the building.

Building typology

It targets large buildings (larger than 2322m^2), both residential and non-residential. The law incrementally expands the share of buildings that are covered by the requirement: 20% of buildings in 2024-2029 and 75% of buildings in 2030-2034.

Compliance mechanisms

Large-building owners must annually report energy and water consumption in compliance with the NYC Benchmarking law (Local Law 84). In the Energy Start Portfolio Management System, where this data is uploaded, the energy use is transposed in kilograms of carbon equivalents ($kgCO_2eq$). The building emission law specifies carbon intensity limits per building segments in these terms. These reports will be checked by the office for energy performance and emissions performance. When buildings exceed the annual buildings emission limit, the owner is liable for a civil penalty equal to the difference between the emission limit for that year and the reported emissions in tonnes of CO_2 multiplied by $268.

A separate office of building energy and emissions performance within the New York City department of buildings has been created to oversee the implementation of the new energy performance-related policies. This office is charged with monitoring buildings energy use and emissions, reviewing building emissions assessment methodologies, building emission limits, goals, and timeframes to further the goal of achieving the emission targets.

Key success factors

- Low-interest loans available through a new Property Assessed Clean Energy programme to finance energy efficiency and green energy through a special assessment on a building's property tax bill.
- Available financial subsidies to support the various measures, including 'green roof tax abatement'.
- The GPRO training programme, a national training and certificate program, trains professionals in sustainable techniques and high-performance construction and maintenance practices.
- City-owned buildings will lead by example and follow stricter rules, with a target of 50% reduction in 2030.

[39] Local Law 97. (2019). New York City Council.

Building Performance Ordinance

Boulder, Colorado, USA

The Building Performance Ordinance (Ordinance No. 8071)[40] is important in the context of the Boulder Building Performance Program.[41] To reduce GHG emissions and increase the energy efficiency of the building stock, the ordinance requires owners of commercial, city and industrial buildings to:

- Annually report the energy usage of their buildings,
- Perform periodic energy assessments
- Perform periodic retro-commissioning and implement cost-effective energy efficiency measures
- Implement one-time lighting upgrades.

Legal provision

The legal provisions part of the Building Performance Program can be divided into two categories: the annual rating and reporting of building energy usage and the implementation of energy efficiency requirements.

The implementation of energy efficiency requirements consists of three parts[42]:

1. Implement one-time lighting upgrade in line with City of Boulder Energy Conversation Code.

2. Perform a quality energy assessment every 10 years, tuning up buildings and calibrating existing functional systems to run as efficiently as possible.

3. Implement cost-effective retro-commissioning measures. The ordinance obliges building owners to implement cost-effective measures within two years after the audit. Cost-effective is defined as each measure with a payback period of two years or less with rebates.

Building typology

- All municipal buildings larger than 460m^2 floor area
- New buildings with a floor surface larger than 930m^2
- All commercial and industrial properties larger than 1850m^2.

[40] Boulder Building Performance Ordinance. (2015). City of Boulder.
[41] Boulder Building Performance Program. (2020) City of Boulder.
[42] Boulder Building Performance Ordinance no. 8071. (2020). Buildingrating.org

Compliance mechanisms

Failure to report on energy data of buildings before the building typology related deadlines results in fines of \$0.027/m^2, up to a maximum of \$1000 per building per day of non-compliance.

Key success factors

- A wide set of support resources, including training programmes for portfolio management, municipal training programmes, assistance for dealing with the split-incentive dilemma and green leases.
- Rebates and other financial instruments to support the implementation, like the level II Energy Assessment Rebates, Excel Energy Retro-commissioning
- Incentives, C-PACE Financing, Boulder County PACE Rebates, solar rebates and grants, clean energy loans and Xcel Energy Prescriptive Rebates.

Oceania

In Australia and New Zealand different types of MEPS are being implemented (see table 14). Where some focus on public buildings, e.g. the Green Lease Schedules in Australia, the recent adoption of new MEPS legislation focuses mostly on the rental sector to improve the health and well-being of tenants, e.g. the Residential Tenancies Regulations (AUS) and the Healthy Homes Guarantee Act (NZ). Metrics relate to minimum insulation values (R-values) and the efficiency and capacity of installations. Compliance is based on specific dates by which building owners must comply, as presented in the below Table.

Table F.4: Overview of MEPS analysed in Oceania

Name/description of requirement	Location	Building type	Metric	Effective	Compliance category
Green Lease Schedules / National Green Leasing Policy	Australia	Non-residential	NABERS energy rating	2010	Enforcement calendar
Residential Tenancies Regulations 2020	Victoria, Australia	Residential	To be confirmed	2021	TBC*
Healthy Homes Guarantee Act	New Zealand	Residential	Minimum -temperature (°C) -insulation thickness (mm) -ventilation (openable windows/mechanic ventilation) -moisture (effective drainage)	2021	Enforcement calendar

Green Lease Schedules,

Australia

To improve energy efficiency and environmental impacts of government operations, the Australian government enacted the Energy Efficiency in Government Operations (EEGO) policy. The policy aims to overcome traditional barriers to improve the energy efficiency of buildings like the split-incentive dilemma by enabling parties with influence on the building to benefit from implementing improvements. The aim of the policy is to:

1. Reduce energy intensity in operations by 25% in offices
2. Achieve a 20% reduction of energy consumption in office central services by 2021.

Legal provision

The introduced 'Green Leases'[43] contain mutual obligations for tenants and owners of office buildings to achieve efficiency targets. The scheme aims to improve energy efficiency by setting a minimum operational building energy performance standard (i.e the Australian Building Greenhouse Rating – ABGR).[44]

Minimum energy performance requirements for premises above 2000m^2 are a minimum of 4.5 stars within ABGR, which is equivalent to 'excellent' energy performance.

Building typology

All leased government properties and other government buildings.

Compliance mechanisms

Yearly reports on the energy usage of operations made by agencies every financial year, by fuel type and end-use category.

Key success factors

- Public buildings are leading by example.
- Templates for green lease schedules.

Healthy Homes Guarantee Act,

New Zealand

The aim of the Healthy Homes Guarantee Act[45] is to ensure healthy, dry and warm rental buildings in New Zealand. The Act includes requirements for rental buildings to have a

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[43] Green Lease Schedules. (2010). Forms and templates
[44] Australian Government (2017). Factsheet - Green Lease Schedule
[45] Healthy Homes Guarantee Act. (2017). Government of New Zealand.

fixed heating device with a specified capacity, minimum underfloor and ceiling insulation, and ventilation requirements.

Legal provision

These objectives of the act are to be achieved through the '[Healthy Home Standards](#)'[46], in which MEPS for heating, insulation and ventilation is specified. This 'Residential Tenancies (Healthy Homes Standards) Regulation' became law in July 2019.

The standards prescribe that the heating system must be fixed and able to heat the living space, have a minimum capacity of 1.5 kW, have a thermostat and meet a prescribed minimum heating capacity based on living space building characteristics (Schedule 2)[16]. The insulation must have a minimum R-value (ranging between 2.9 – 3.3 for ceiling insulation and 1.3 for underfloor) depending on the climatic zone. Ventilation requirements relate to the presence of windows and doors that can be opened next to requirements for mechanical ventilation in kitchens (>50L/s) and bathrooms (>25L/s). Additional requirements exist for draught stopping and drainage.

Building typology

Rental buildings in the residential sector

Compliance mechanisms

Compliance dates are formulated for heating, insulation and ventilation and specified for building typologies (e.g. social rent, private rent, etc.). Information about compliance is available on the webpage of the government of New Zealand.[47]

Key success factors

- Addresses the whole rental market.

1.6.Detailed description of options for MEPS

In this section the options for MEPS which have been included in Chapter 5.2 are described in more detail.

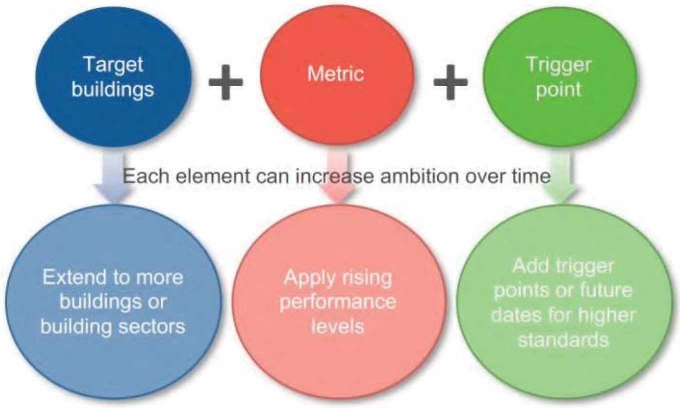
For the identification of options, three main criteria were identified: the target buildings, the metric and the trigger point. As regards the **target buildings**, MEPS can apply to the whole building stock or specific sectors, building types of privately or publicly owned stock. One specific segment is that of buildings subject to transaction (being sold, rented). Buildings could also be selected based on their size, with the advantage of economy of scale resulting from renovations and interventions on larger buildings units.

[46] Residential Tenancies (Healthy Homes Standards) Regulations. (2019). Government of New Zealand.

[47] Healthy Homes Standards Webpage. (2020). Ministry of Housing and Urban Development New Zealand.

As regards the **metric for the setting of standards**, the options are either based on the energy rating based on EPC or on the energy performance applied to the technical building systems in place in the building (e.g. heating and cooling appliances, HVACs, etc.). While other options would be technically possible, there are clear advantages in using the same performance metrics which are already enshrined in the EPBD. The EPC framework is the most obvious reference point for introducing MEPS for existing buildings, as all EU Member States have implemented and enforced national energy performance certificate (EPC) schemes[48], and most building owners know about EPCs and the infrastructure to roll them out (experts, compliance, databases etc.) is already in place. The UK was first to set a minimum energy efficiency standard based on the EPC rating, followed by France, Belgium and the Netherlands.

Figure F.10: Approach and key design criteria for MEPS[49]



As for **trigger points**, MEPS could be linked to specific moments of the life-cycle of buildings (e.g. sale or rent, major renovation or new installations) or specific dates of entry into force of the requirement could be established, which could tighten over time. Thanks to gradual tightening, MEPS incrementally improve the performance of the stock along a roadmap to decarbonisation. MEPS could therefore complement the requirements already existing on minimum energy performance in case of major renovations (Art. 7) or new installations (Art. 8). When introduced with a clear indication of the future trajectory of rising standards, MEPS can also illustrate a pathway for building owners to renovate towards climate-neutral buildings early. The clear standards and future trajectory also provide the much-needed planning horizon for industry and building trades to boost the supply of skilled professionals and innovative renovation solutions.

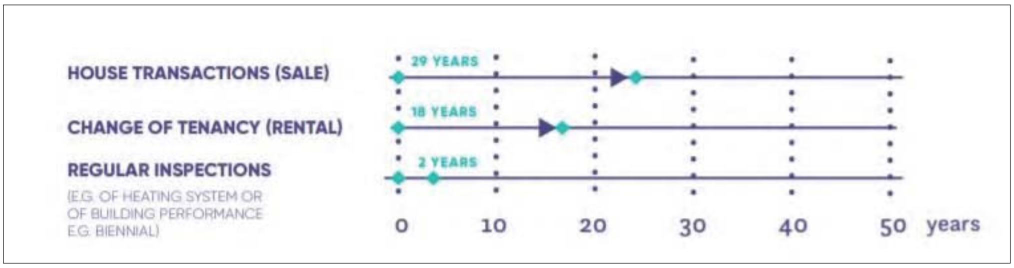
In the first option (**MEPS1**), the standard introduced in the EPBD will require MSs to ensure that buildings will be sold or rented only if they respect a minimum energy performance level. This approach exploits specific moments in the lifetime of

[48] All MS have an EPC framework and a framework for setting minimum energy performance requirements, based on a calculation of cost-optimal levels of energy performance.
[49] Sunderland et al. (2021).

investments in buildings – trigger points – when the cost and hassle associated with building renovation are less substantial, thus minimising the main barriers for increasing renovation. It had been assessed that the hurdles to renovation can be diminished if these are carried out in key moments in the life of a building, as renovations can become less disruptive and more economically advantageous than at other moments[50].
More specifically, as regards the instrument and metric based on which to set the standard, MEPS could be set on the basis of the EPC class rating in place in each MSs. In the first compliance period, the energy performance standard could be set at the level of performance as defined in the range for a specific class, for example at EPC class D (depending on the specific ranges established by the national schemes). Alternatively, the standard could refer to the phase out of the two lowest class(es) in the national rating. The minimum performance standards could be tightened over time, in line with the goal of driving the progressive upgrade of the buildings stock.

This approach will generate more effects (in terms of increased energy renovations and overall reductions of energy consumption and carbon emissions) and more obligations to upgrade the performance of the buildings in the countries in which the number of transactions is high, and in which the overall energy performance of the building stock subject to transaction is lower. On average, it has been estimated that each home in Europe will be sold only once between now and 2050, with varying frequencies across countries[51]. The change of tenancy happens instead more frequently (on average every 18 years).

Figure F.11: Timeline of trigger points for renovations[52]



All buildings types (both residential and non-residential, including the public ones) will be subject to the applicable standard. The obligated parties will be the buyer of the buildings, in case of sales, and the building owner in the case of buildings being rented. The ability to transfer the obligation from the seller to the buyer removes the burden of renovation from those who are unable to afford or manage an energy renovation before selling, and takes advantage of the trigger point of non-energy renovation, extension and

[50] BPIE, 2017. Trigger points as a "must" in national renovation strategies.
[51] Frequency of sales based on 221 million households in EU (Eurostat, 2020), 65% of homes are owner-occupied (Housing Europe, 2017) and approximately 5 million house transactions per year (European Central Bank, 2020). Frequency of change of tenancy based on 25-44% of tenants moved in five years (Eurostat, 2017).
[52] Adapted from Kruit et al., 2020

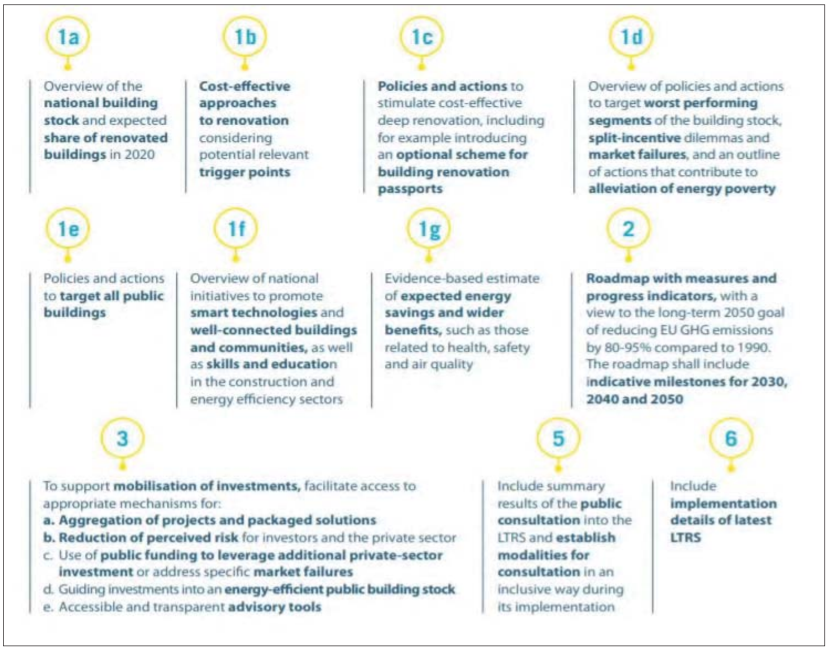
improvement undertaken by home buyers[53]. The MEPS framework should in this case foresee that a certain period of time is allowed to the obligated parties to comply with the obligations, and to do the necessary renovation works which would allow to upgrade the performance to the required level. This flexibility would allow obligated parties to plan the renovation at the most convenient moment, and to distribute in time the demand for renovations which will be generated with the entry into force of the standard.

Specific exclusions should be applied, to take into account of buildings that due to technical constraints could not be renovated to achieve the standards set. The exemption regime could mirror the provisions already in place under Article 4 of the EPBD, for instance in relation to historical buildings.

Another consideration related to the building type, is that this approach for setting standards would be difficult to apply as such to multifamily and multi-apartment buildings. Currently 48,9%[54] of the dwellings in the EU are multi-family buildings, of which 70% are owner occupied while the remaining can be distinguished between "tenant occupied dwellings, with rent at market price" (18,9%), and "tenant occupied dwellings, with rent at reduced price or free (11%)[55]. Specific application measures should be foreseen for MEPS to promote collaboration of all unit owners to carry out renovations in multifamily buildings and there could be difficulties in aligning that with the transaction of the building. The need for specific provisions for buildings of the residential sectors with a more complex ownership structure than single-family buildings is likely to be present also for all other types of MEPS.

Figure F.12: Overview of LTRS provisions in the EPBD[56]

[53] Sunderland L., Santini M. (2021); Next steps for MEPS: Designing minimum energy performance standards for European buildings. Regulatory Assistance Project, June 2021.
[54] Data from BSO, EU SILC.
[55] Data from JRC (2018), Energy efficiency upgrades in multi-owner residential buildings. Review of governance and legal issues in 7 EU Member States.
[56] BPIE (2020): A review of EU MS' 2020 Long Term Renovation Strategies.

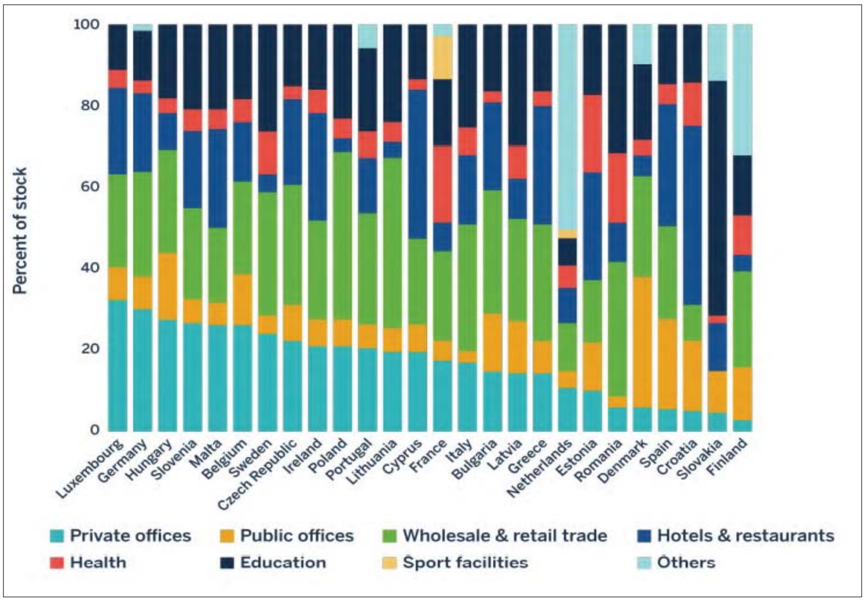


Both options **MEPS2** and **MEPS3** foresee an approach to set standards that relies on criteria and a timeline of implementation and compliance deadlines established in the EPBD, while the level of ambition of the standards and the more specific implementing provisions would be defined at national level. The national MEPS would have and be coherent with the overall goal of decarbonisation and of achieving a highly energy efficient and decarbonised building stock by 2050, which is also at the core of the national Long-Term Renovation strategies. Also in this option it is foreseen that EPC would be the main instrument of the national MEPS framework on the basis of which to set the standard and to ensure compliance.

The EPBD should establish overall criteria and goals to be achieved by MEPS respectively by 2030, 2040 and 2050, which could build on the milestones and numerical pledges identified by MSs in their LTRS. In this way MEPS will become an instrument supporting the achievement of the milestones identified and clearly driving the deployment of investment towards them.

Figure F.13: Distribution of non-residential floor area by use (2013)[57]

[57] Building Stock Observatory (BSO).



Source: Building Stock Observatory

The criteria for setting national MEPS could be based on an amount of savings (energy or carbon) to be achieved under a clear timeline, or identify a number of buildings or floor area to be renovated annually (fleet approach). National MEPS could establish the gradual phase-in into the MEPS framework of different buildings segment, on the basis of the specificities of the national building stock. As LTRS also define worst-performing buildings segments, these could become the specific target of MEPS. National MEPS schemes applying to all the building stock could also target buildings segments in such a way to maximise the social benefits that their renovation entails, for instance by setting standards first to buildings with a specific social function, e.g. social housing, schools or hospitals.

The two options **MEPS2** and **MEPS3** differ for the target buildings, which are limited to non-residential buildings above a certain size in MEPS3. Residential buildings make up 75% of the EU floor area, with non-domestic buildings making up the remaining 25%. Public buildings make up around 2% share of non-domestic buildings in the majority of Member States. This approach would leave out the vast majority of buildings in the EU and would change significantly because the largest share of regulated entities would be businesses or real estate owning buildings used in the commercial, services and buildings sector, thus excluding households of home owners. The fact that the scope would be limited to buildings above a certain size would also likely to exclude SMEs or very small businesses with small facilities (start-up, micro-enterprises).

Differently from the other options which foresee that the metric is the overall energy performance based on the EPC class, **MEPS4** has a more narrow scope as it is based instead on the performance of the heating and cooling appliance installed in the building or dwelling. The trigger point of application is their planned replacement, which could be done only with appliances which are best in class based on their Energy Label, or be based on carbon emission performance levels. The rationale of this option is that a significant energy saving potential and reduction in carbon emissions can be achieved thanks to highly efficient heating and cooling appliances. On average, space heating products are replaced every 17 years[58], therefore while planned replacements offer a good opportunity and a natural "trigger point" to upgrade the energy performance of the buildings, they still happen at a low pace and often they are replaced with a similar appliance.

A drawback of this approach is that MEPS scheme targeting only appliances could lead to lock-ins or suboptimal solutions in comparison to interventions which integrate also interventions to the building shell. As indicated in a comprehensive study that looked at energy savings potentials in the residential sector, by 2030, EU residential sector has a technical saving potential of 33%, reducing BAU final energy consumption by 77 Mtoe, and an economic saving potential of 15%, reducing BAU final energy consumption by 36 Mtoe[59]. Space heating presents highest amount of technical and economic energy saving potential and several of the energy savings opportunities identified combine improved wall/attic/basement insulation, reducing air infiltration with high performance technical systems and appliances. Uptake of efficient heat pumps presents the next most significant energy savings amounting to 23% energy savings of space heating category.

This option can be implemented by specific requirements in the EPBD, building on the existing provisions on technical building systems under Article 8 and compliance can be ensured via the inspections mechanisms already foreseen. Another relevant provision in this context is also Article 7 of the Energy Labelling Regulation (EU) 2017/1369 setting a framework for energy labelling provides, which in its Article 7 foresees that where Member States provide incentives for a product specified in a delegated act, those incentives shall aim at the highest two significantly populated classes of energy efficiency, or at higher classes as laid down in that delegated act.

Currently, several buildings installations are covered by ecodesign and Energy Labelling requirements. As regards space heating, it has been estimated that 70% - 80% of the EU heat load is covered by products which are currently covered by Ecodesign and Energy Labelling provisions[60]. District heating and very large appliances, e.g. boilers over 400

[58] VHK (2020); Ecodesign Impact Accounting, 2019 Report.
[59] ICF (2020, under publication).
[60] The 'heat load' that space heating solutions have to deliver was estimated of around 2400 TWh and the space cooling load around 220-260 TWh. The heat load is calculated looking at the surface area, climate and average indoor temperature. As regards climate, almost two-thirds of the EU population lives in a relatively mild climate. Around 10% live in a colder winter-climate, in Eastern and Northern regions or in mountain areas. One quarter of Europeans live in a warm Mediterranean climate. Almost 70% live in a city, which is 1-2°C warmer than the countryside and 41% live in coastal regions, which is also warmer in winter. In Europe, the average outdoor temperature is 6.5°C during the 7 months buildings are heated (5 months in a warm climate, 9 months in a colder climate). The average indoor temperature, 24/7 and over all rooms, is 18°C. This means that on average heating systems are required to offset a temperature

kW are not covered, but these are anyway not technologies which could be replaced based on decisions from the buildings' owner, and therefore it could be assumed that Energy Label provides a solid base to set MEPS on heating and cooling installations.

difference of 11.5°C. The sun and the heat from people and equipment inside the buildings increase 3.5°C. On average 8°C is needed from the heating system during the heating season, to compensate for the heat dissipated through the building shell (60%) and the cold air entering the building from ventilation and infiltration (40%). These are EU-averages, i.e. the proportion between transmission and ventilation losses varies and depends on the insulation and type of ventilation (e.g. windows or mechanical). For individual cases also the orientation, wind, etc. are relevant. VHK (2020); Ecodesign Impact Accounting, 2019 Report.

Annex G: Energy Performance Certificates (EPC)

1. The existing framework and status for EPCs

1.1 Background

The EPBD aims at creating a demand-driven market for energy efficient buildings, with the provision of information through certification and other tools. Energy Performance Certificates schemes must be in operation for the issue, hand-over to the buyer or tenant and display of energy performance certificates (EPCs). EPCs intend to provide information to building owners and tenants on the energy performance of their buildings and on effective ways to improve these through building renovation works. Qualification schemes for experts, quality control and enforcement must be ensured, in particular through national independent control systems that Member States have set up in line with the EPBD. Providing users with the relevant information help them to take the best decisions.

However, energy performance certification of buildings should not be viewed as a goal in itself, but as a key instrument to support and monitor the policy implementation and enforcement. Building rating programmes are considered to have greatest impact when integrated into a strategic and coordinated energy efficiency policy framework[61]. The relevance of such instrument is therefore conditioned to its better integration into the regulatory framework (e.g. to minimum standards) and to broader initiatives designed to tackle multiple barriers (information campaigns and financial support).

First initiated by the EU in the early 1990s, Energy Performance Certificates (EPCs) have evolved as a core policy tool for driving energy performance and efficiency in the building sector. Although this impact assessment focuses on the areas for improvement of EPCs, it should not be underestimated that the current system is of great value, as it sets a uniform EU legislation requiring that EPCs are available in all MS. For example, the calculation of the energy performance of buildings is based on the same principles set up in the EPBD. The EPC is further supported by the development of the Energy Performance of Buildings Standards (EN) ISO 52000 series. Even if there are some differences in implementation in different MS, it ensures that an energy performance assessment method with a common ground is being used in all MS, which is not the case

[61] IEA, 2010, Policy Pathways, Energy Performance Certification of Buildings

for other assessment methods (i.e. commercial rating systems) which have different coverage in different countries.

An EPC must be issued for all buildings or building units which are sold, or rented out to a new tenant. The EPC must include the energy performance of a building (in kWh/(m^2 year) and recommendations for improvement. EPCs must include the energy performance of a building and its reference values as well as recommendations for the cost-optimal or cost-effective improvements of the energy performance of a building or building units. In regard to value and trustworthiness, Member States are mandated to ensure that EPCs are carried out in an independent manner by appropriately qualified and/or accredited experts. Furthermore, all Member States must develop independent control inspections for EPCs (Annex II of the EPBD). The EPC may include additional indicators such as CO_2 emissions or the percentage of renewable from energy sources.

The idea behind EPCs is that they inform relevant actors, such as building owners, tenants and real estate agents, about the energy performance of their buildings which in turn shapes the building market. However, only around 10% of buildings in Europe possess an EPC[62] and the quality of EPCs varies considerably across the EU. It is necessary to improve reliability and increase the scope of EPCs to include and display a building's CO_2 performance, history and a more likely outlook of its energy use and demand-side flexibility readiness. Upgrading EPC databases is important to improve understanding of the overall performance of the built environment.

In the evaluation carried out in 201663 in preparation of the previous review of the EPBD it was concluded that the certification schemes for the energy performance of buildings have proven some effects in transforming the real-estate market. However, the evaluation identified weaknesses and several ways of reinforcing the role that EPCs can play, e.g. to facilitate compliance checking, to improve the efficiency of financing schemes, and to contribute to gathering data and build statistics on national building stocks.

1.2 Summary of main EPC provisions

EPCs are covered in the following articles in the EPBD:

- Art. 11 Energy Performance Certificates
- Art. 12 Issue of Energy Performance Certificates
- Art. 13 Display of Energy Performance Certificates
- Art. 17 Independent Experts
- Art.18 Independent Control System

[62] BPIE et al. (2020), Lessons learned to inform integrated approaches for the renovation and modernisation of the built environment, ENER/C3/2019-468/03, December 2020.
[63] SWD(2016) 408 final

EPCs are also covered in the following Annexes:

- Annex I Common general framework for the calculation of energy performance of buildings
- Annex II Independent control systems for energy performance certificates and inspection reports

Article 10 (Financial incentives and market barriers), makes a specific reference to EPCs, encouraging its use to prove the energy savings of energy performance improvements that are subject to financial support.

An EPC must be issued upon construction, sale or rent of a building to the new owner or occupier. The EPC must be shown to the prospective owner or tenant and its value must be stated in advertisement media.

Multi-residential buildings (i.e. building blocks) are allowed to have a common EPC based on the whole building (if it shares a heating system), or individual EPCs which can be based on a similar unit with the same energy characteristics. Single-family homes may have an EPC based on a building of similar design and performance, but only if this similarity can be guaranteed by an accredited energy assessor.

Since 2010, buildings over 500 m^2 occupied by a public authority public authority and frequently visited by the public must issue an EPC. The size threshold fell to 250m2 after 9th July 2015. This EPC must be displayed in a prominent place clearly visible to the public.

1.3 Coverage of EPCs

Based on publicly available EPC databases, together with overviews provided by public authorities, the X-Tendo project gathered and compiled EPC label information for more than 45 million residential EPCs. Information provided by national authorities suggests that around six million residential EPCs are issued every year. In EU the most EPCs per capita are achieved by Belgium, Ireland, Denmark and Portugal.

The relatively low number of EPCs in some countries can be explained by several reasons[64]:

- The EPC database is rather new and thus few EPCs have been registered (e.g. Finland).
- In some countries, the compliance rate is still relatively low for residential buildings which hampers the uptake of EPCs (e.g. Latvia, Bulgaria).
- The number of real estate transactions influences the number of issued EPCs. The real estate market in the UK is one of the most liquid and has the highest number

[64] Source: Concerted Action EPBD: https://epbd-ca.eu/. Based on information provided by Member States.

of transactions (as well as the shortest ownership period), which triggers many new EPCs.

- In Bulgaria, the complex ownership structures in multifamily buildings (the most common building type in the country) make it difficult to get an EPC. As a result, EPCs are mainly attained if the building owners are planning to apply for a public renovation grant for which the EPC is a prerequisite.
- The country is relatively small with a low total number of buildings (e.g. Malta and Estonia).

Figure G.1: total number of EPCs (in thousands)[65][66]

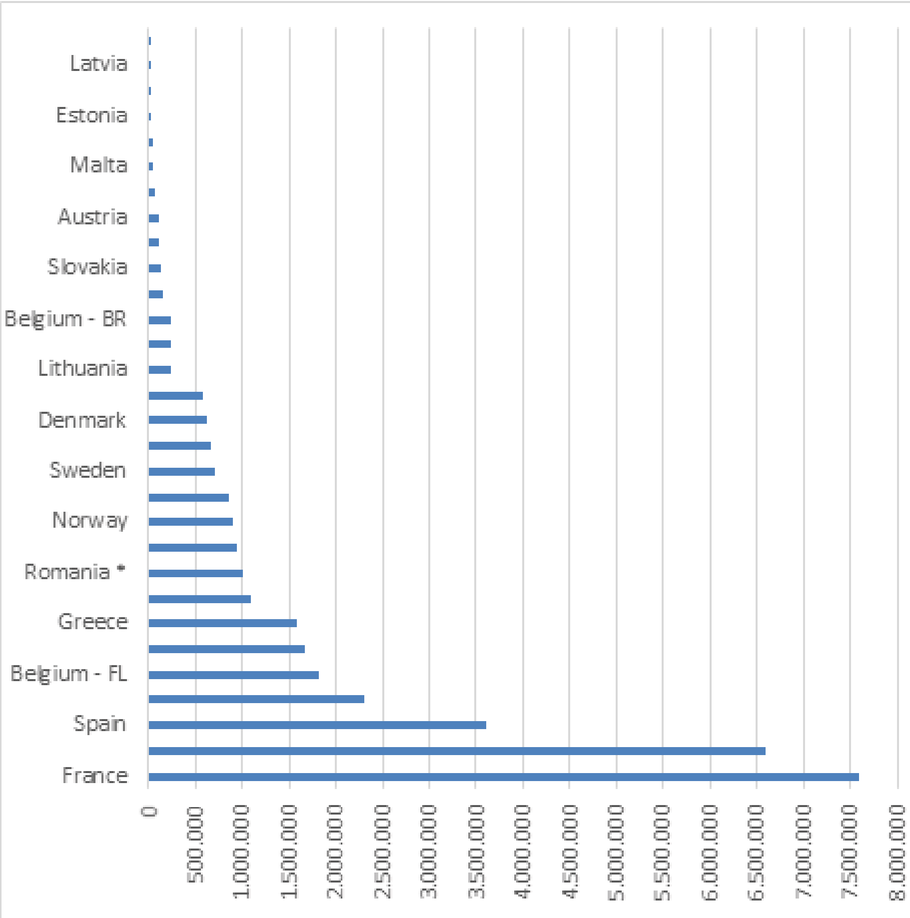


Figure G.2: Total number of registered EPCs per capita in EU and UK [67]

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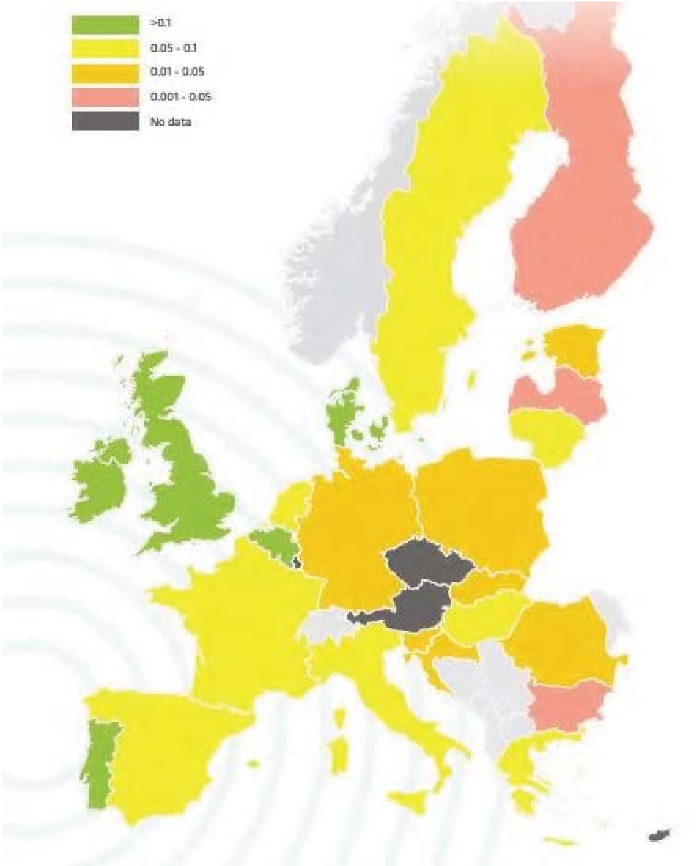
[66] Countries with * are estimates or based on partial information

[67] Source: EPC numbers come from EPBD CA Key Implementation Decisions (KIDs) and information provided by X-tendo partners. 2018 populations from Eurostat.



1.4 Comparability of EPC classes

There are differences between EU member states with regards to the calculation of EPCs and how results are presented. This variability in calculation and differences in results has reduced the confidence of some stakeholders in the capacity of the EPC to establish comparative energy efficiency analysis between MS. Moves across Europe to ensure compliance with international targets are being reflected in a tightening of regulatory frameworks[68].

The rating methodologies vary across Europe. In 2021, the JRC censed 29 EPC methodologies used in the European Union (with individual methodologies in each member state and then for the Flanders, Wallonia and Brussels regions within Belgium). Consequently, the metrics for the grading of EPCs are non-standard. Most Member States use primary energy in kWh/(m^2 year) as the main indicator. However, there are differences in how the different classes are defined. In some MS they are defined based on bands of kWh/(m^2 year), while in others they are defined based on a comparison with NZEB values or on comparison with reference buildings (e.g. specific % of NZEB value). For 2 Member States, there are no classes, but rather a continuous grading.

[68] RICS (2019); Energy efficiency and residential values: a changing European landscape.

Further, in some jurisdictions (such as Germany, Spain and Italy), there are within-country variations.

When the methodology for calculating energy performance and the scaling and labelling differs from Member State to Member State, and sometimes from region to region, the same building placed in different Member States, e.g. two different sides of a national/regional border could differ in rating, with the same climate conditions. As a result of varying methodologies, a residence in Ireland with an energy efficiency performance of 75 kWh/(m^2 year) would be given an EPC rating of A, whereas in Germany a residence with the same performance metric would be given a rating of B. This would be an issue for any cross-border financial institution.

EPC labels have been designed to reflect the existing building stock and the characteristics of this building stock (particularly regarding energy performance). Even when using the same methodology and scale, buildings between countries are not always directly comparable, due to the differences in climate and use.

The 2016 evaluation concluded that EPCs had not yet succeeded in supporting a comparable pan-European market for buildings energy efficiency investments nor led to reduction of related transaction costs. The primary underlying reason is to be found in the lack of harmonised national calculation methodologies that determine the energy rating that is included in the EPC. This is equally true for investments into non-residential buildings or for the bundling of smaller scales investments in the residential sector, which need underlying standards to rate the quality of the bundle based on the quality of its parts.

The 2016 evaluation concluded also that it could be questioned whether the requirement to establish national EPC schemes has resulted in efficient implementation. Differences in transposition and implementation have resulted in in different layouts for labels and recommendations across Member States and regions. EPCs have a different layout and content in different EU Member States, though most countries have implemented an A-G scheme similar to the EU energy labelling for energy using products. Even when label layouts are similar, the rating of the building cannot always be compared across Member States as they are based on a different energy performance calculation methodology. These differences result also in a loss of confidence on the reliability of the EPC, regardless of the individual merits of the different EPC schemes. There is a case for better comparability across Member States to drive investments in the most energy efficient buildings.

For market participants in the non-residential sector, which are often multinational property owners and development companies, the need for comparability is to some extent being tackled through a voluntary common European Union certification scheme for the energy performance of non-residential buildings (Article 11(9) of the EPBD). This common scheme, based on CEN standards for calculating the energy performance of buildings, would allow for a consistent comparison of different buildings' energy use across borders. The adoption of this scheme was not considered a priority in 2018 as the provisions for EPCs were not being substantially modified. The revision in 2018 instead concentrated on implementation measures and renovation and modernisation of buildings.

The EPC4EU data model, funded through Horizon 2020, is developing a tool for the harmonisation and the interoperability of EPC databases across the EU. *Table G.1 Values of EPC labels for residential buildings across the EU (Values of A+++, I and J have been cut out for 3 MS)*

Member State	A++	A+	A	B	C	D	E	F
AT	60	70	80	160	220	280	340	
BE-BRU	0	45	85	170	255	340	425	
BE-FLA		0	100	200	300	400	500	
BE-WALL	0	45	85	170	255	340	425	
BG		48	95	190	240	290	363	
HR		15	25	50	100	150	200	
CY			0,50	1,00	1,50	2,00	2,50	
CZ			0,50	0,75	1,00	1,50	2,00	
DK	20	30+1000/A	52,5+1650/A	70+2200/A	110+3200/A	150+4200/A	190+5200/A	24
EE			100	125	150	180	220	
FI			75	100	130	160	190	
FR			50	90	150	230	330	
DE		25	50	75	100	135	165	
EL		0,33	0,50	1,00	1,41	1,82	2,27	
HU	40	60	80	100	130	160	200	
IE	25	50	75	150	225	300	380	
IT	0,60	0,80	1,00	1,20	1,50	2,00	2,60	
LV			40	60	80	100	150	
LT	C1 < 0.3; C2 ≤ 0.70;	C1 < 0.5; C2 ≤ 0.80;	C1 < 0.7; C2 ≤ 0.85;	C1 < 1; C2 ≤ 0.99;	C1 < 1.5;	C1 < 2;	C1 < 2.5;	
LU	---	---	45	95	125	145	210	
MT	---	---	---	---	---	---	---	
NL	139	194	292	361	444	556	667	
PL	---	---	---	---	---	---	---	
PT		0,25	0,50	0,75	1,00	1,50	2,00	
RO		82	115	228	344	459	574	
SK		70	140	279	419	558	698	
SI		10	15	35	60	105	150	
ES			36	63	103	161	291	
SE			25	42	69	109	227	

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1.4.1 Calculation of energy saving improvements across classes

Table G.2 (below) reports the energy savings necessary to improve the energy performance class of buildings. This calculation is relevant with reference to the application of MEPS and more specifically MEPS1 options.

In general, EPC schemes follow under one of these categories:

- Schemes that use (kWh/m^2 year) as their indicator and have defined energy classes by (kWh/m^2 year).
- Schemes (e.g. ES, IT and PT) that use (kWh/m^2 year) as their indicator and the energy classes are dependent on the climatic region[69].
- Schemes that use (kWh/m^2 year) as their indicator and use a continuous grading system (no energy classes).
- Schemes that use relative or dimensionless values as their indicator and uses a reference values to define the energy classes[70].
- Schemes that use reference buildings for the calculation of the performance and use reference values to define the energy classes[71].
- Schemes for which the information available is limited and as a result it is not possible to determine exactly how their systems operate.

The calculation makes the following assumptions:

- The value for the buildings in the lowest class is 10% worse than the absolute limiting value between the lowest class and 2nd lowest class (e.g. in most cases between G and E). The lowest class is always open ended, and existing buildings can have values of energy performance which are much worse than the limiting value. This is considered a conservative estimate.
- The upgrade takes the building to the absolute limit between class D and class E. This is considered a conservative yet realistic estimate as many building owners may not be willing to renovate the building beyond what is strictly necessary.
- For residential buildings, the calculation uses single-residential buildings or the average between single and multi-residential buildings.
- For non-residential buildings, the calculation uses the value for offices or commercial buildings.

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[69] For these MS the analysis refers to the label from their capitals. This may result in some differences for other regions, but it is representative in terms of % of improvement.

[70] For example: Class A is 25% of the national reference value or Class B is the NZEB value for the country.

[71] A reference building is a notional building with the same geometry, orientation and general characteristics as the building under evaluation. The reference building has a series of pre-determined energy performance characteristics. The class is determined by how much better the calculated building is when compared to the reference building (e.g. 25% better). It is not always possible to transform this value into a kWh/m^2 figure. Where possible, the calculations has allowed for assumptions in order to provide representative values (e.g. based on statistical information for the Member State).

Overall, these assumptions result in a conservative analysis, with a bias towards lower energy savings. Where reference values or reference buildings are used, the calculation has made specific assumptions based on available information.

Residential buildings

Available data:

- 20 schemes with direct values
- 3 schemes with estimated values using the capital as representative (ES, IT and PT)
- 3 schemes with estimated values based on reference buildings or reference values (CY, CZ, EL)
- 3 schemes with unclear information or continuous rating (LT, MT and PL)

Total: 26 MS with reliable information. The results are considered as representative at EU level.

Table G.2: Energy performance classes in EPC, kWh/m2y (residential buildings)[72]

	A	B	C	D	E	F	G	Value
AT	80	160	220	280	340	400	>400	Direct
BE-BRU	85	170	255	340	425	510	>510	Direct
BE-FLA	100	200	300	400	500	>500		Direct
BE-WALL	85	170	255	340	425	510	>510	Direct
BG	95	190	240	290	363	435	>435	Direct
HR	25	50	100	150	200	250	>250	Direct
CY	0,50	1,00	1,50	2,00	2,50	3,00	>3,00	Estimate
CZ	0,50	0,75	1,00	1,50	2,00	2,50	2,50	Estimate
DK	52,5+1650/A	70+2200/A	110+3200/A	150+4200/A	190+5200/A	240+6500/A	>240+6500/A	Direct
EE	100	125	150	180	220	280	340	Direct
FI	75	100	130	160	190	240	>240	Direct
FR	50	90	150	230	330	450	>450	Direct
DE	50	75	100	135	165	200	250	Direct
EL	0,50	1,00	1,41	1,82	2,27	2,73	>2,73	Estimate
HU	80	100	130	160	200	250	310	Direct
IE	75	150	225	300	380	450	>450	Direct
IT	1,00	1,20	1,50	2,00	2,60	3,50	>3,50	Estimate
LV	40	60	80	100	150	>150		Direct

[72] Some countries also have A+++, A++, A+, H, I, J classes or sub-classes (e.g. B1 and B2). For simplicity purposes, the table does not report these values.

LT	---	---	---	---	---	---	---	No value
LU	45	95	125	145	210	298	395	Direct
MT	---	---	---	---	---	---	---	No value
NL	292	361	444	556	667	806	>806	Direct
PL	---	---	---	---	---	---	---	No value
PT	0,50	0,75	1,00	1,50	2,00	2,50	2,51	Estimate
RO	115	228	344	459	574	689	690	Direct
SK	140	279	419	558	698	837	>837	Direct
SI	15	35	60	105	150	210	>210	Direct
ES	36	63	103	161	291	367	367	Estimate
SE	25	42	69	109	227	247	247	Direct

Table G.3: Energy performance classes in EPC, kWh/m2y (residential buildings)[73]

	EPC levels (kWh/m²)				kWh/m²			%		
	C	D	E	Worst class +10%	Upgrade to C	Upgrade to D	Upgrade to E	Upgrade to C	Upgrade to D	Upgrade to E
AT	220	280	340	440	220	160	100	50%	36%	23%
BE-BRU	255	340	425	561	306	221	136	55%	39%	24%
BE-FLA	300	400	500	550	250	150	50	45%	27%	9%
BE-WALL	255	340	425	561	306	221	136	55%	39%	24%
BG	240	290	363	479	239	189	116	50%	39%	24%
HR	100	150	200	275	175	125	75	64%	45%	27%
CY	150	200	250	330	180	130	80	55%	39%	24%
CZ	115	173	230	316	201	144	86	64%	45%	27%
DK	142	192	242	336	194	144	94	58%	43%	28%
EE	150	180	220	375	225	195	155	60%	52%	41%
FI	130	160	190	264	134	104	74	51%	39%	28%
FR	150	230	330	495	345	265	165	70%	54%	33%
DE	100	135	165	275	175	140	110	64%	51%	40%
EL	93	120	150	198	105	78	48	53%	39%	24%
HU	130	160	200	550	420	390	350	76%	71%	64%
IE	225	300	380	495	270	195	115	55%	39%	23%
IT	44	59	77	114	69	55	37	61%	48%	32%
LV	80	100	150	165	85	65	15	52%	39%	9%
LT	---	---	---	---	---	---	---	---	---	---
LU	125	145	210	583	458	438	373	79%	75%	64%

[73] Some countries also have A+++, A++, A+, H, I, J classes or sub-classes (e.g. B1 and B2). For simplicity purposes, the table does not report these values.

MT	---	---	---	---	---	---	---	---	---	---
NL	444	556	667	887	443	331	220	50%	37%	25%
PL	---	---	---	---	---	---	---	---	---	---
PT	97	146	194	267	170	121	73	64%	45%	27%
RO	344	459	574	759	416	300	186	55%	40%	24%
SK	257	342	428	564	308	222	137	55%	39%	24%
SI	60	105	150	231	171	126	81	74%	55%	35%
ES	86	135	259	338	252	203	79	75%	60%	23%
SE	69	109	227	272	203	163	45	75%	60%	17%

As a summary, at EU level[74] the calculations suggest:

- - 60% energy savings to bring buildings to Class C
- - 46% energy savings to bring buildings to Class D
- - 29% energy savings to bring buildings to Class E

The results also show significant variability across countries, with a range of savings to bring from worst Class to Class E between 9% and 41%.

Results for non-residential buildings

- 15 schemes with direct values
- 1 scheme with estimated values using the capital as representative (PT)
- 7 schemes with estimated values based on reference buildings or reference values
- 6 schemes with unclear information or continuous rating (BE-WAL, DE, LT, MT, NL and PL)

The information is more limited than for residential buildings (Total: 23 MS with reliable information). However, the number and distribution between MS would suggest that the results are representative for the whole of the EU.

Table G.4: Energy performance classes in EPC, kWh/m2y (non-residential buildings)[75]

	A	B	C	D	E	F	G	Value
AT	80	160	220	280	340	400	>400	Direct
BE-BRU	62	155	248	341	434	527	>527	Direct
BE-FLA	100	200	300	400	500	>500		Direct
BE-WALL	---	---	---	---	---	---	---	No value
BG	140	280	340	400	500	600	>600	Direct
HR	25	50	100	150	200	250	>250	Direct

[74] The calculation gives equal weight to all EPC schemes (i.e. there is no weight values according to the size of the building stock)
[75] Some countries also have A+++, A++, A+, H, I, J classes or sub-classes (e.g. B1 and B2). For simplicity purposes, the table does not report these values.

	A	B	C	D	E	F	G	Value
CY	0,50	1,00	1,50	2,00	2,50	3,00	>3,00	Estimate
CZ	0,50	0,75	1,00	1,50	2,00	2,50	>2,50	Estimate
DK	71,3+165 0/A	95+220 0/A	135+32 00/A	175+42 00/A	215+52 00/A	265+65 00/A	>265+6 500/A	Direct
EE	100	130	150	180	220	280	>340	Direct
FI	80	120	170	200	240	300	>300	Direct
FR	50	110	210	350	540	750	>750	Direct
DE	---	---	---	---	---	---	---	No value
EL	0,50	1,00	1,41	1,82	2,27	2,73	>2,73	Estimate
HU	80	100	130	160	200	250	310	Direct
IE	0,50	1,00	1,50	2,00	2,50	3,00	>3,00	Estimate
IT	1,00	1,20	1,50	2,00	2,60	3,50	>3,50	Estimate
LV	45	65	90	110	150	>150		Direct
LT	---	---	---	---	---	---	---	No value
LU	45	75	85	100	155	225	280	Direct
MT	---	---	---	---	---	---	---	No value
NL	---	---	---	---	---	---	---	No value
PL	---	---	---	---	---	---	---	No value
PT	0,50	0,75	1,00	1,50	2,00	2,50	2,51	Estimate
RO	97	193	302	410	511	614	615	Direct
SK	122	255	383	511	639	766	>766	Direct
SI	15	35	60	105	150	210	>210	Direct
ES	0,40	0,65	1,00	1,30	1,60	2,00	2,00	Estimate
SE	0,50	0,75	1,00	1,35	1,80	2,35	>2,35	Estimate

Table G.5: Improvement required to upgrade buildings between classes (non-residential buildings)

	EPC levels (kWh/m²)				kWh/m²			%		
	C	D	E	Worst class +10%	Upgrade to C	Upgrade to D	Upgrade to E	Upgrade to C	Upgrade to D	Upgrade to E
AT	220	280	340	440	220	160	100	50%	36%	23%
BE-BRU	248	341	434	580	332	239	146	57%	41%	25%
BE-FLA	300	400	500	550	250	150	50	45%	27%	9%
BE-WALL	---	---	---	---	---	---	---	---	---	---
BG	340	400	500	660	320	260	160	48%	39%	24%
HR	40	60	80	110	70	50	30	64%	45%	27%
CY	188	250	313	413	225	163	100	55%	39%	24%
CZ	122	183	244	336	214	153	92	64%	45%	27%
DK	138	179	220	299	160	119	78	54%	40%	26%
EE	150	180	220	375	225	195	155	60%	52%	41%

	EPC levels (kWh/m²)					kWh/m²			%		
FI	170	200	240	330		160	130	90	48%	39%	27%
FR	210	350	540	825		615	475	285	75%	58%	35%
DE	---	---	---	---		---	---	---	---	---	---
EL	93	120	150	198		105	78	48	53%	39%	24%
HU	130	160	200	550		420	390	350	76%	71%	64%
IE	375	500	625	825		450	325	200	55%	39%	24%
IT	136	181	235	348		212	167	113	61%	48%	32%
LV	90	110	150	165		75	55	15	45%	33%	9%
LT	---	---	---	---		---	---	---	---	---	---
LU	85	100	155	391		306	291	236	78%	74%	60%
MT	---	---	---	---		---	---	---	---	---	---
NL	---	---	---	---		---	---	---	---	---	---
PL	---	---	---	---		---	---	---	---	---	---
PT	273	410	546	754		481	344	208	64%	46%	28%
RO	302	410	511	677		375	267	166	55%	39%	24%
SK	360	480	600	792		432	312	192	55%	39%	24%
SI	60	105	150	231		171	126	81	74%	55%	35%
ES	156	203	250	344		188	141	94	55%	41%	27%
SE	100	135	180	259		159	124	79	61%	48%	30%

As a summary, at EU level[76] the calculations suggest:

- - 59% energy savings to bring buildings to Class C
- - 45% energy savings to bring buildings to Class D
- - 29% energy savings to bring buildings to Class E

The results also show significant variability across countries, with a range of savings to bring from worst Class to Class E between 9% and 64%.

1.5 Scope of information in EPCs

The EPC is defined in the EPBD as "a certificate recognised by a Member State or by a legal person designated by it, which indicates the energy performance of a building or building unit, calculated according to a methodology adopted in accordance with Article 3". The calculation methodology in Article 3 is referring to Annex 1: Common general framework for the calculation of energy performance of buildings.

[76] The calculation gives equal weight to all EPC schemes (i.e. there is no weight values according to the size of the building stock)

The EPC is required when buildings are newly constructed, sold or rented out and is valid for a maximum of 10 years. The EPC must be shown to prospective buyers or tenants and must be stated in advertisement media.

The main provisions regarding the information available in an EPC are described in Articles 11 to 13 and Annex 1 of the EPBD:

- Requirement for EPCs to include the energy performance and reference values to make it possible for owners or tenants of the building to compare and assess its energy performance.
- Requirement that the energy performance of a building is expressed by a numeric indicator of primary energy use in (kWh/m^2 year). This is the same indicator for EPCs and for compliance with minimum energy performance requirements.
- Possibility for EPCs to include additional information such as the energy consumption, the percentage of renewable sources in the total energy consumption, or the operational greenhouses gas emissions.
- Requirement to include recommendations for improvements of the energy performance of buildings.

EPC recommendations should include specific building elements as well as major renovations comprising multiple building elements and building systems. These measures must be cost-optimal. EPCs must provide information about the work needed to implement the recommendations and they must say where more detailed information can be found. Estimates of cost savings resulting from improvements must also be included, and a forecast of underlying energy prices.

1.5.1 Operational CO_2

The calculation of operational GHG is based CO_2-emission coefficients which are set by MS for different energy carriers (e.g. gas, electricity and district heating). The coefficients are applied to the primary energy consumption already calculated for the EPC. A number of MS have already introduced operational CO_2 elements in their schemes.

According to the CA EPBD, 18 MS have set a CO_2 emission coefficient for gas, and the value varies between 160 and 252 g CO_2 per kWh.

Similarly, 12 MS have set a CO_2 emission coefficient for electricity, and the value varies between 0 and 644 g CO_2 per kWh. 6 MS are planning to update the CO_2 emission coefficient for electricity.

9 MS have set a CO_2 emission coefficient for district heating, and the value varies between 154 and 400 g CO_2 per kWh. 3 MS plan to introduce a coefficient for district heating.

6 MS are monitoring CO_2 emission savings after the renovation of buildings receiving public support, and 3 additional MS are planning to introduce this monitoring.

The introduction of indicators for operational CO_2 would be a straightforward process, even for MS that have not developed the coefficients. In addition, due to the fact that the primary energy demand is one of the main elements of EPCs, in most cases, it would be possible to calculate the operational CO_2 for EPCs already stored in databases.

1.5.2 Embedded CO_2

Embodied carbon is the carbon dioxide (CO_2) emissions associated with materials and construction processes throughout the whole lifecycle of a building or infrastructure. A Life cycle assessment (LCA) is used to calculate the whole-life carbon of a building. This methodology makes it possible to assess environmental impacts and resource consumption at each stage of the building's lifecycle, from material extraction to construction and use, to the demolishing of the building. The LCA can also include an assessment of the potential benefits from the reuse or recycling of components after the end of a building's useful life.

Several Member States are considering or have regulated embodied carbon emissions.

The Commission has developed the Level(s) tool[77] to assess and report on sustainability aspects throughout the lifetime of buildings. The objective is to provide a common language on sustainability and circularity for buildings. Level(s) offers an extensively tested system for measuring and supporting improvements, from design to end of life. It can be applied to residential buildings or offices.

The embedded carbon aspects are further developed in Annex H.

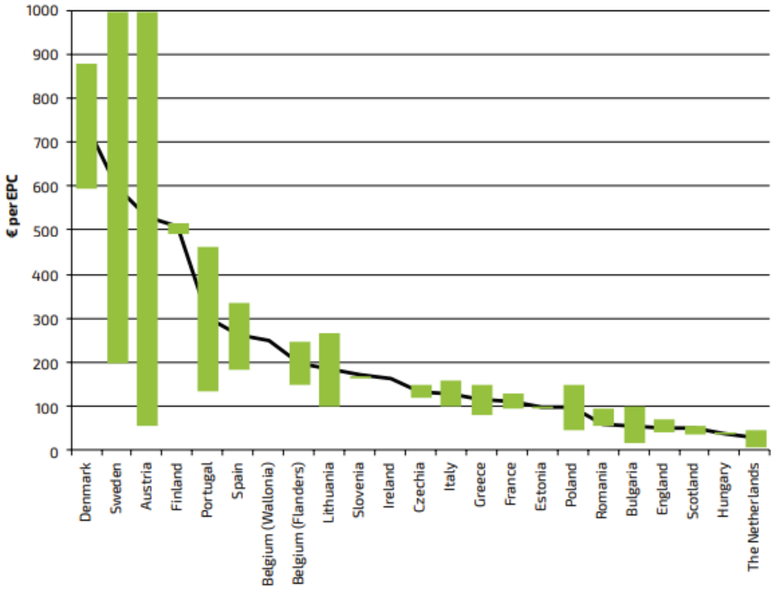
1.6 Cost of EPCs

EPC prices are generally set on a market basis with no maximum ceiling. A small number of Member States, including Denmark, Croatia, Hungary and Slovenia, have regulated the cost for an EPC. In Denmark, the cost is capped at €884 for larger single-family buildings and in Slovenia at €170 for one-dwelling and two-dwelling buildings. In Hungary, the cost of an EPC for apartments and single-family buildings is set by law (€40 + VAT per unit). Experts have criticised this as unrealistically low, undermining the quality of the certificate. The below Figure shows that the cost ranges from €20 to €1000 for a single-family house EPC across the EU. The variation can be explained by factors such as quality/comprehensiveness of the EPC methodology, variation in labour cost across the EU, number of competing actors on the market, cost of EPC software,

[77] https://ec.europa.eu/environment/levels_en

involvement of trained experts, on-site audits, verification by an independent organisation, registration or not in a national EPC database, etc.

Figure G.4: Cost range for an EPC for a single-family house[78]



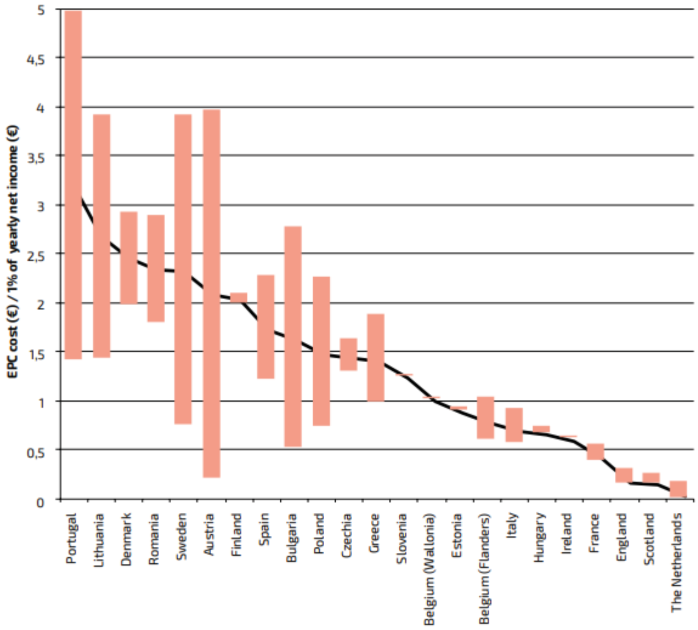
Source: X-Tendo EU project based on own sources and CA EPBD

Figure G.4 shows the cost of an EPC in relation to the average net income in the country. Building owners in Portugal, Lithuania and Denmark pay relatively the most for their EPC, while owners in the Netherlands pay relatively less.

Figure G.5: Cost range for an EPC for a single-family house, based on per-capita income[79].

[78] Sources: X-tendo based on own sources and CA EPBD

[79] Sources: X-tendo based on own sources and CA EPBD.



Source: X-Tendo EU project based on own sources and CA EPBD

1.7 Use of EPCs by financial investors

The JRC[80] assessed that financial investors currently use EPCs to a large extent. In particular, EPCs are utilized to establish a rough baseline prior to conducting an extensive building audit. They do not replace a building audit, but allow for a general idea of what buildings might be of interest to audit. EPCs may also be used as a mapping tool to identify clients with the largest investment potential in terms of environmental and/or social impact. For example, investors named utilizing public EPC data (when available) to find low rated households in order to offer them retrofits and maximise social benefit as well as their return on investment. Investors will usually only pro-actively seek out energy efficiency investments in this way when they also partially or fully own a project developer. Therefore, the EPC is a useful mapping tool enabling them to better target client outreach.

There are certain banks that are experimenting with providing green mortgages. This means that they take into account the increased value of a home after a renovation and energy efficiency upgrade when providing a mortgage. As a result, the mortgages may be offered at lower rates. A home may be taken from an EPC grade E to a grade B; however, the quantification of value is based on the energy cost reductions assumptions provided by the building audit (not the EPC rating). The rating is a means of expressing the improvement in the condition of the building.

[80] Stromback, J., Hobson, D., Streng, E., Ribeiro Serrenho, T. and Bertoldi, P., Advanced quality and use of energy performance certificates (EPCs) by investors and financial institutions, EUR 30886 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-43380-4 (online), doi:10.2760/151167 (online), JRC125031.

However, the following criticisms were made by investors interviewed, which were considered as limiting substantially the potential more extended use of EPCs:

- Absence of mandatory use policies for financial institutions and funds81.
- Lack of consistency in the availability of EPCs (sometimes they are not available or available too late in the process).
- Lack of set timeframes for improvements or buildings to reach certain rating, to encourage definite refurbishments and increase finance.
- Lack of standardisation across European Union Member States, making comparability of results difficult
- Lack of clear regulation around quality of EPC rating methodologies. Issues around unreliability and inaccuracy. For example, self-reporting allowed in certain Member States, (such as over the phone, without any visit from an inspector to the property).
- Lack of assurance of qualified personnel performing the EPC audit. Unequal, low or inconstant requirements and thresholds for becoming a licensed EPC issuer/inspector. The implication for financial institutions is a consequent risk in quality assurance.
- Lack of detail and robust quantification. EPCs are considered overly simplistic for use in financial analysis. Out of all the flaws named in the course of this study, lack of detail was the most frequently mentioned.
- Methodologies do not enable funds to quantify value or the impact on an EPC rating of a specific renovation plan.
- Methodologies are not granular enough to consider the impact or value of individual energy efficiency measures such as improved heating, cooling or lighting.

A study by the Energy Efficient Mortgage Initiative suggests that EE ratings complement rather than substitute borrower credit information and that a lender who uses information from both sources (borrower credit information and EE ratings) can make superior lending decisions compared to lenders who do not exhaust all available information[82].[83]

The introduction of the EU Green Taxonomy is an important recent development that is likely to have a significant impact in the use of EPCs. In particular, the Taxonomy requires the use of EPC to certify the necessary level of performance for new buildings or real estate operations, or to certify the improvement in case of renovations. Notwithstanding its identified weaknesses, the EPC presented a number of key elements

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[81] The same analysis from JRC had also identified that although not mandatory several national schemes already refer to EPC class for eligibility or compliance with financial incentives.
[82] EEMI, "Buildings' Energy Efficiency and the Probability of Mortgage Default: The Dutch Case"
[83] Zancanella, P., Bertoldi, P. and Boza-Kiss, B., Energy efficiency, the value of buildings and the payment default risk, EUR 29471 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-97751-0, doi:10.2760/267367, JRC113215.

for its use in the taxonomy: embedded in legislation in all EU MS, with the administrative support this represents, most extensively use approach across the EU and relative low cost.

1.8 EPCs and consumer's behaviour

Evidence shows that there are multiple barriers that deter people from upgrading the energy efficiency of their homes. These include the complexity of the renovation process, the disruption to the household's routine, the financial cost involved, as well as homeowners' lack of trust in new technologies and lack of confidence to engage contractors as well as homeowners' cognitive biases[84]. While there are a large number of households with savings potential, the combined effects of the barriers result in a much smaller number of households actually retrofitting their homes. Each of these barriers can be addressed through intervention in the form of incentives, information, communication, and standards, leading to an increase the number of households undertaking home energy upgrades each year. EPCs are an important information tool in this context.

Research shows that a well-designed EPC can influence homeowners to renovate[85]. Using graphics and colours to help the end-user grasp the information in the EPC can increase its perceived usefulness. Italy and Portugal use this to highlight certain content in the EPC[86].

Paying attention to the way information is provided is important. As an example, with categorical-scales (like those in terms of A-G classes), according to a study, consumers often value the class, but neglect the underlying differences in energy consumption[87].

Continuous-scales, by presenting information on energy efficiency more accurately and avoiding the "class valuation effect", can, according to a study, be more likely to enable more rational decisions (that is consumers are more able to make comparisons of the options available and finally decide to invest)[88].

Including information on environmental impact might grasp the attention of environmentally concerned citizens who will understand that retrofitting is a way to

[84] Boza-Kiss, B., Bertoldi, P., Della Valle, N. and Economidou, M., One-stop shops for residential building energy renovation in the EU, EUR 30762 EN, JRC125380

[85] V. Taranu and G. Verbeeck, "A closer look into the European Energy Performance Certificates under the lenses of behavioural insights—a comparative analysis," Energy Efficiency 11 (7), 1745-1761, 2016.

[86] Italy: The energy performance of the building envelope is shown in the Italian EPC with qualitative "smileys", indicating its ability to thermally insulate the interior (in winter and summer conditions). The rating scale is divided into three values: high quality, medium quality or low quality, represented by the smileys. Portugal: Innovative indicators include renewable energy use and CO2 footprint, which are both featured on the front page of Portugal's EPC.

[87] Andor, M. A., Frondel, M., Gerster, A., & Sommer, S. (2019). Cognitive reflection and the valuation of energy efficiency. Energy Economics, 84, 104527

[88] He, Shutong, et al. "Energy Labels and Heuristic Decision-Making: The Role of Cognition and Energy Literacy." USAEE Working Paper Series (2020)

protect the environment[89]. This has been shown from examples in Spain, where CO_2 emissions are included[90]

In the public consultation, stakeholders raised concerns about citizens' lack of understanding of the EPCs. According to some stakeholders, homeowners or tenants often have problems assessing the informative value of EPC or deriving specific action from them. A possible solution put forward by stakeholders is that EPCs should provide information on building's actual energy performance, in addition to the calculated performance.

A research study investigated this further for the case of Belgium, Wallonia[91], and proposed modifications to the EPC calculation methodology to take into account user behavior. The U-CERT project[92] is currently working on a next generation EPC including measured energy use and cost data and connected user behavior data. In some MS, for instance in Sweden, the EPC is based on measured data accompanied with a methodology to take into account the user behavioral aspects.

2 POLICY OPTIONS FOR EPCS

Overall the objectives are to increase the number of buildings with an EPC, as well as their quality and comparability for investors across Member States. The increased coverage should go hand in hand with higher quality of EPCs as fully digital tools. An extended range of information should be included in all EPCs to be issued.

2.1 Strengthening quality, reliability and comparability

The table below summarises the options for improvement identified to ensure a better quality, reliability, and comparability through a progressive harmonisation of EPCs.

Table G.6: Overview of policy options A.3 on Quality, reliability and comparability of EPCs

A.3 Quality, reliability and comparability of EPCs			
No.	Policy options	Timeline	Detailed description

[89] Della Valle, N. and Bertoldi, P., Mobilizing citizens to invest in energy efficiency, EUR 30675 EN, Publications Office of the European Union

[90] V. Taranu and G. Verbeeck, "A closer look into the European Energy Performance Certificates under the lenses of behavioural insights—a comparative analysis," Energy Efficiency 11 (7), 1745-1761, 2016

[91] S. Monfils, J-M Hauglustaine "Introduction of behavioral parameterization in the EPC calculation method and assessment of five typical urban houses in Wallonia, Belgium", 2016

[92] https://u-certproject.eu/

No.	Policy options	Timeline	Detailed description
EPCQ1	Voluntary measures to increase quality[93] and harmonisation of EPCs	*Up to MS*	• Introduce in the EPBD a voluntary common EU template (Machine readable, Database compatible) • Voluntary harmonisation of EPC classes (Best EPC class needs to be 2050 compatible)
EPCQ2	Mandatory measures to increase quality and voluntary harmonisation	MS to implement by 2025	• Introduce in the EPBD a mandatory common EU template (Machine readable, Database compatible) • Voluntary harmonisation of EPC classes (Best EPC class needs to be 2050 compatible)
EPCQ3	Mandatory measures to increase quality and harmonisation of EPCs + Reporting obligations	MS to implement by 2025	• Introduce in the EPBD a mandatory common EU template (Machine readable, Database compatible) • Mandatory harmonisation of EPC classes (Best EPC class needs to be 2050 compatible) Mandatory quality control measures amongst the following: • Mandatory visits to produce EPC • Improved quality control • Minimum % of controlled EPCs (sample)[94] • Possible use of metered data as control Reporting obligations

2.1.1 Why is it necessary to improve quality and comparability?

As indicated in section 1.4 “Comparability of EPC classes”, the limiting values for EPC classes attributed to buildings vary significantly across countries, thus limiting their value to investors and financial actors that operate in multiple markets. The differences between classes are also difficult to understand, which can undermine the confidence on EPC schemes regardless of the actual quality of the schemes.

In the context of the 2016 evaluation, most of the Member States' experts agreed that EPCs are important tools both for linking the energy efficiency investments with housing prices and for checking compliance. However, experts agreed on the need for improving EPC reliability. Experts agreed that developments in the product technologies can also further facilitate compliance.

EPCs can be a valuable tool for assessing the level of compliance with building codes and enable efficient compliance check by providing information to central bodies. EPCs are already being used for this purpose (e.g. EPC at design face to obtain building permits). This has been facilitated with the amendment introduced in the 2018 revision. The amended EPBD required Member States to report their calculation methodologies (including EPCs) in line with the ISO 52003-1, “Indicators, requirements, ratings and

[93] Modification to Annex II (improve Annex II, include references to targeted mechanisms, but still leave significant flexibility).
[94] Increase from “statistically significant” to e.g. 10%.

certificates". Several MS have taken this opportunity to improve their building performance methodologies and existing indicators (CA EPBD). Examples of improvements are related to the energy performance requirements, energy performance calculations and procedures, EPC label and scale, EPC layout, energy performance indicators. 15 MS use calculated values for the assessment of the energy performance and 12 MS use a combination of calculated and measured values. Around 40% of MS have adopted or are expected to adopt ISO standards related to indicators, requirements and ratings (ISO 52000-1, ISO 52003-1, ISO 52018-1).The evaluation also showed that certification of the energy performance of buildings is delivering a demand-driven market signal for energy efficient buildings and is achieving its aim to encourage consumers to buy or rent more energy efficient buildings. However, national certification schemes and independent control systems were at early stages in several Member States and their usefulness could be enhanced.

The quality of EPCs as a reporting tool is directly linked to the national methodology and the quality of the application and reporting process. This appears to vary widely. For example, one Spanish investor stated that they do not use EPCs in Spain due to the fact that metrics are self-reported by the developers or building owners. Others such as a Belgium bank, find them to be useful benchmarking tools[95].

The recent adoption of the EU Green Taxonomy, which makes extensive use of the EPC to certify the requirements on new buildings, buildings undergoing renovation and real estate activities, puts additional pressure on the need for quality and reliable EPCs.

At a stakeholder workshop 19 May 2021 stakeholders in a poll replied that quality and reliability of EPCs are the most important aspects to work on in the revision.

2.1.2 Current provisions on quality control

Requirements for quality control were first introduced in the EPBD in 2002 and then updated in the EPBD Recast of 2010. The provisions regarding the independent control system are establishes in Article 18, while Annex II provides further information on the characteristics of the independent control system. The first provision is the obligation to verify a random selection of at least a statistically significant percentage of all the EPCs issued annually. The second provision describes the 3 different options in which the verification must be based:

- Verification option 1: validity check of the input data.
- Verification option 2: check of the input data and verification of the results.

[95] Stromback, J., Hobson, D., Streng, E., Ribeiro Serrenho, T. and Bertoldi, P., Advanced quality and use of energy performance certificates (EPCs) by investors and financial institutions, EUR 30886 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-43380-4 (online), doi:10.2760/151167 (online), JRC125031.

- Verification option 3: full check of the input data, full verification of results, and on-site visit.

The objective of this stepped verification is to determine if:

- The input data generates an EPC of a different value. This would identify if the EPC or the software providing the EPC have internal errors or have been tampered with.
- The input values for the EPC are within an acceptable range which corresponds to the characteristics of the building (e.g. typology, age, type of systems, expected performance of components. This would identify an EPC in which the input data is incorrect (e.g. value of insulation too high, performance of boiler too high).
- The input values for the EPC are checked against evidence (e.g. building plans, boiler specifications, on site inspection).

While the EPBD describes some elements and key provisions of an independent control system, the EPBD does not:

- Define what is the minimum level of quality of an EPC (e.g. an EPC is correct if it is within ± 10% of the value established by the independent control system)
- Define a level of confidence that schemes should achieve (e.g. the random sample determines with 95% confidence that the EPCs in a given year are within acceptable limits)
- Establish an obligation to report to the general public on the work carried out by the independent control system
- Establish an obligation to report to the EC on the work carried out by the independent control system

The EPBD recast in 2010 strengthened the quality assurance requirements. The 2018 amendments reiterates that "The current independent control systems for energy performance certificates can be used for compliance checking and should be strengthened to ensure certificates are of good quality".

The implementation of effective systems of quality assurance is a challenging task. It needs to be considered at every stage of the certification process i.e. training and control of auditors, quality check in the software, verification of the certificates issued. At the same time, the cost of the system should be balanced in order to avoid a significant increase in the certificates' cost. Data inaccuracies can be caused by lack of competence of the EPC expert, procedures not being properly followed, incorrect on-site measurements, incorrect assessment of building elements, application of wrong pre-calculated values in the methodology or intentional miss-application to obtain specific results (i.e. fraud)[96].

The lack of clear quality criteria and reporting results in poor perception of the required quality levels that EPCs must achieve. In turn, this results in lack of confidence on EPC schemes. The lack of public reporting or reporting to the European Commission results in limited available information on the approach and results of the different independent control systems. This also results in poor confidence in the overall EPC scheme.

Increasing trust and establishing a good reputation for the EPC among building owners, potential tenants and other market actors is a challenge that needs to be further addressed.

Examples of control systems in Member States

Denmark: The Danish energy agency publishes a yearly report on the main results of the independent control system. The Danish scheme defines a valid EPC as an EPC that is within the correct label. The sample size is determined by a statistic uncertainty of ±7.5% and a confidence level of 95%. In 2018 the Danish energy agency carried out a deep evaluation of 121 EPCs, representing 0.2% of the total of EPCs issued in 2018 (60 320). This is in addition to a number of automated and other minor checks.

Proportion of checked energy labels for existing buildings correctly positioned on the scale:

2016	2017	2018
69 %	79 %	77 %

In 2017 and 2018 just over 20% of the EPCs were incorrectly labelled, an improvement over the 30% of incorrectly labelled EPCs in 2016. Upon enquiry by DG-ENER, the Danish energy agency informed that the majority of incorrect EPCs very close in terms of the absolute value (kWh/m2). Due to the discreet type of labelling (i.e. based on the label of EPC and not on the numerical value) a small change in value could result in a change in the category.
In 2019, the Danish energy agency changed the approach for the analysis of EPCs. Instead of a random sample, the agency took a targeted approach, selecting EPCs that were deemed more at risk. A total of 127488 EPCs were issued in Denmark in 2019. From these, the agency selected 215 for more detailed evaluation, representing 0.17%. Out of the 215 EPCs evaluated, 200 were deemed incorrect.

Estonia: The Consumer Protection and Technical Regulatory Authority is tasked to randomly check the quality of the issued EPCs. More checks are conducted on EPCs issued by experts where inadequate quality or “foul play” is suspected.

Flanders: The Flemish Energy Agency executes random and targeted checks of the presence of an EPC (when legally required), the credentials of experts and the EPC’s compliance with the defined methodology.

Germany: An independent control system was introduced in 2014. A statistically significant sample of

[96] X-tendo project.

certificates is randomly selected from the EPC register, which includes the EPC's identification number and the contact details of the EPC assessors. Checks at all levels can only be performed after the responsible assessor of the selected EPC has provided additional input. Therefore, experts are required to store all relevant data for at least two years after the EPC has been issued.

Greece: Quality control is performed at the first step through random checks on data entry. By law, the randomly selected sample is 5% of the total of EPCs issued. Random checks are also conducted on-site, whenever required, depending on desk check results and in case of complaint.

Italy: The quality control varies from region to region. All the regions and autonomous provinces with a regional EPC database (i.e. Bolzano, Campania, Emilia Romagna, Friuli-Venezia Giulia, Lazio, Liguria, Lombardia, Piemonte, Toscana, Trento, Valle d'Aosta, Veneto) perform at least an "input/ documentary data control". In seven of the regions on-site controls are performed, with different procedures and different targets; some regions control randomly, while others control on-site every new building and deep building renovation. Some regions control on-site when anomalies in the energy performance indexes are found, or in the case of buildings with very high energy performance levels.

Romania: The State Inspectorate for Construction (ISC) has been assigned to randomly control 10% of the EPCs and energy audits issued annually. So far, they have covered less than 1% (as reported in trimester ISC reports). The Romanian Association of Energy Auditors for Buildings signed a voluntary agreement to help ISC in assessing the technical quality of controlled documents, but this was rarely requested.

Source: European Commission and X-tendo project

2.1.3 Options for strengthening quality

On the basis on the recommendation of several project that have looked at possible improvements of quality control measures, the following possible measures have been identified:

- Mandatory visits to produce EPC
- Define a minimum level of quality for EPCs
- Define a minimum level of confidence for the independent control scheme
- Obligation to carry out automated and targeted controls
- Quality control to include site-visit
- Possible use of metered data as control
- Reporting of the independent control schemes

The EPBD does not require a site visit to produce an EPC. Although many aspects of an EPC can be gathered through desk search, it is preferable in most cases to check that the information coincides with the situation on site. For existing buildings, a site visit may be particularly necessary as information may be missing, which would require the independent expert to make on-site measurements.

As indicated above, the EPBD does not define what is considered a correct EPC. A common definition with common criteria across the EU would support quality schemes, allow for cross-comparison and increase the overall confidence in the scheme.

As regards sampling, the verification of EPCs can be carried out on a random or targeted sample basis. Random verification, as the name suggests, implies a random selection of EPCs which are then evaluated for their correctness. Random verification allows for the determination of the quality levels of the overall EPCs for a given period. Sampling could also be based on the building typology.

Targeted verification, as the name suggests, implies that the selection of EPCs for their verification follows specific criteria. The criteria may include elements such as targeting EPCs that include elements out of typically expected range (e.g. insulation too high for a building of a certain age), foul play or systemic errors. Targeted selection offers the advantage of being capable of detecting more defective EPCs for a given sample size. This results in a more cost-effective (i.e. cost of inspection per defective EPC detected). The disadvantage of targeted verification is that it only focuses on specific areas of the overall population. If the selection criteria are not adequately selected and kept up to date, the system may be miss-targeting areas.

In summary: random selection allows for the analysis of the overall quality level of the sample (and the total population by example), while targeted selection is a more cost-effective solution to detect defective EPCs. Both methods can be combined in a quality assurance scheme.

The EPBD does not require site visits as part of the independent control system, although they are indicated as one of the options. Site visits offer the best chance of detecting inaccuracies in an EPC, particularly if there are differences between as designed (i.e. what is on the plans) and as built (what is actually in the building). They also increase the confidence in the system as they offer the most complete assessment and increase the perception of involvement. Site visits, however, are more costly than automated or desk checks. Overall, an obligation to include a minimum level of site visits would significantly support the confidence in EPC independent control systems.

As indicated above, there is currently no obligation to report on the performance of the EPC independent control systems. This results in perception of EPC being a “black box”, where inputs and outputs are commonly misunderstood. This has a negative effect in the quality and overall reliability of the EPC scheme. The reporting on the overall quality levels and the corrective and improvement measures, would increase accountability and transparency of the quality measures in place, the overall scheme.

2.1.4 Policy options for strengthening comparability

As shown in Table 1, there are large variations among MS as regards EPC classes. In order to facilitate comparisons between countries and facilitate for investors it is suggested that a gradual harmonisation of the classes is introduced. Also, for the introduction of MEPS based on EPC classes a gradual harmonisation would be needed.

The EPBD does not include an obligation to define the classes in terms of kWh/(m^2year). A number of MS do use this indicator, there are also examples of MS where the EPC class is defined in relation to the current NZEB requirement or in relation to a reference building (as a percentage of NZEB or reference building values).

The EPBD includes an obligation to indicate the buildings energy performance (kWh/m^2 and year) in the EPC and some MS also include the NZEB value in the EPC to allow for a comparison between the buildings actual energy performance and NZEB levels. One option would be to require that all MS make this comparison between the buildings actual energy performance and NZEB levels, this would allow for some comparisons between MS. However, the value of NZEB is likely to change over time as minimum energy performance requirements are regularly revised. To be noted that in the Commission's Recommendations on NZEBs, it was specifically advised to make a link between NZEBs classes and highest EPCs classes[97].

An alternative option would be to define the A level based on future long-term requirements (e.g. 2050). This would require rescaling in some MS, but would have the advantage of making possible comparisons between MS. It is closely linked to the policy option for defining the future zero emission building (2050 compatible).

A third option is that the classes are equally defined at EU level based on specific values. For example, C level equalling 100 kWh/(m^2year). This could be combined with CO_2-levels for different classes. This option would allow for direct comparisons at EU level and between individual MS, but would require rescaling.

In EPCQ1 and EPCQ2 a voluntary harmonisation is proposed, where the best EPC class needs to be 2050 compatible. In EPCQ3 this harmonisation is mandatory. The timeline proposed is 2025 for EPCQ2 and EPCQ3 whereas the timing is up to MS in EPCQ1.

Several EU-projects are investigating the possibilities of harmonising EPCs or providing comparison tools, such as QualDeEPC, BuiltHub, EUB SuperHub, ALDREN and the EPC4EU data model, see also chapter 3.

2.1.5 Options for strengthening visibility and availability of EPCs

The EPBD requires that:

- The EPC is shown to the prospective buyer, tenant or owner (in case of new buildings)

[97] 'Some Member States have chosen to link the NZEB level to one of the best energy performance classes (e.g. building class A++), as specified in an energy performance certificate. This approach, when accompanied by a clear energy performance indicator, is recommended to give clear information to investors and drive the market towards NZEB.' Commission Recommendation (EU) 2016/1318 of 29 July 2016 on guidelines for the promotion of nearly zero-energy buildings and best practices to ensure that, by 2020, all new buildings are nearly zero-energy buildings.

- The EPC is shown in advertisement media.

While all MS have transposed these requirements in their legislation, compliance rates vary[98].

A potential way to improve compliance is to make it easier for sellers or landlords of buildings to carry out their obligations by providing them with concrete guidelines for the use and presentation of EPCs and the legally required data in advertisements of sales/rentals or buildings/dwellings. In some countries, such guidelines issued by energy agencies/public authorities are already available. For example in Ireland, a detailed guideline plus the respective energy class artwork files have been developed by SEAI and are available for download and use. In France, examples of adverts are available; indicating how the energy label should be presented. The use of a common template and visual identity also supports the recognition of the EPC and the perception of reliability.

Member States check the availability of EPCs at different stages, but there is no consistent approach across the EU. However, sometimes the check is carried out too late in the process. For example, in Belgium, a notary checks the presence of the EPC when finalising a sale operation. This check comes too late in the process as by the time it is provided all decisions (by prospective buyers/tenants, assessors and valuators) have already been taken. Property valuators in particular have identified the lack of information at specific stages as one of the key barriers for a widespread use of EPCs as a tool in property valuation[99].

Information on availability of EPCs in advertising media is scarce. As part of a study on the effects of the EPC in real estate values, ECARES carried out an analysis in Brussels, showing that the presence of the EPC in advertising media was below 15% in 2014[100]. Due to the prevalence of online real estate portals it is relatively easy and cost-effective to carry out machine searches to detect the presence of EPCs. These tools can have great effect on the implementation on the ground. In their 2014 study, BPIE identified that the presence of automated checks in Belgium Flanders increased the presence of EPCs from 68% in 2010 up to 95% in 2015.

2.2 Increase the scope of information and coverage of EPC

Table G.7: Overview of policy options B2 on increase the scope of information and coverage of EPC

B.2 EPCs - Increase the scope of information and coverage of EPC			
No.	Policy action - general	Timeline	Sub-options

[98] QualDeEPC – High-quality Energy Performance Assessment and Certification in Europe Accelerating Deep Energy Renovation
[99] Revalue – designing the next generation of valuation guidance for sustainability in residential property
[100] ECARES – Working paper 2016-2017 - The Rent Impact of Disclosing Energy Performance Certificates: Energy Efficiency and Information Effects

B.2 EPCs - Increase the scope of information and coverage of EPC			
No.	**Policy action - general**	**Timeline**	**Sub-options**
EPCSI1	Additional trigger points for issuing EPCs (building type) + Increase mandatory indicators, with flexibility	MS to implement by 2025	a) All non-residential (incl. public) buildings (Art. 12) b) Contract renewal with existing tenants (residential and non-residential) (Art. 12) MS to choose of the following indicators: CO_2, envelope class (energy need), RES, IEQ, TBS class, SRI
EPCSI2	Additional trigger points for issuing EPCs + Increase mandatory indicators and improve recommendations, with less flexibility + Shorter validity for EPCs	MS to implement by 2025	Trigger points as in EPCSI1+ a) Following renovation (Art 7) b) Changes in technical building system (Art. 8) c) Access to public incentive/funding Additional indicators: <u>Mandatory</u>: operational GHG, total energy use, RES, <u>Voluntary</u>: IEQ, TBS class, SRI, recharging points, energy storage Elements to include in EPC recommendations: • Estimated costs of renovations, savings, other relevant indicators (e.g. GHG, RES), OR point to BRP instead of recommendations Reduce the current 10 year validity (Art. 12)
EPCSI3	All buildings should have EPCs + Increase mandatory indicators and improve recommendations, with less flexibility + Shorter validity for EPCs	MS to implement by 2025	Mandatory target for MS to create EPCs for all buildings (*fee-free obligation*) Reduce the current 10 year validity (Art. 12) Additional indicators: <u>Mandatory</u>: operational GHG, total energy use, RES, <u>Voluntary</u>:, IEQ, TBS class, SRI, recharging points, energy storage Elements to include in EPC recommendations: • Estimated costs of renovations, Energy and cost savings, other relevant indicators (e.g. GHG, RES), OR point to BRP instead of recommendations

2.2.1 Why is it necessary to increase the scope of information and coverage of EPCs?

EPCs are only required at specific moments in the lifetime of a building, which in some cases may never occur across their lifecycle. In addition, the information in EPCs remains limited and is not sufficient to illustrate all the qualities and technologies of the buildings nor the full spectrum of benefit that improvements could bring. The overall carbon performance is for instance not a compulsory element in EPCs. As a consequence, these important aspects are also not adequately reflected in property values.

Currently the only mandatory indicator in the EPC is energy use expressed in (kWh/m^2 year). This is not enough for users such as home owners, investors and policymakers to make the right decisions for the achievement of 2030 and 2050 targets on emission reduction and other objectives in the Green Deal.

The need for additional indicators and improved recommendations in the EPCs is strongly linked to the proposed introduction of Building Renovation Passports (BRP). BRPs are complementary to the EPC and can drive the uptake of EPCs, especially if accompanied by financial measures.

To address the information barriers related to the current energy performance of buildings that were identified in the problem definition, it is necessary to increase the number of buildings that has an EPC. The uptake today is low and there is a big variation between MS, as described in the first chapter of this Annex.

Increasing the scope of information and coverage of Energy Performance Certificates will also help to ensure that public support such as EU funding can be better targeted towards high-impact projects and qualitative investments; it will also facilitate the follow up in terms of reporting and monitoring and long term impact of public support to building renovation.

2.2.2 Policy options to increase the number of buildings with an EPC

The policy options to increase the diffusion of EPCs and therefore the share of the building stock having an EPCs are the following:

- *Require EPC for all non-residential buildings or Mandate MS to create EPCs for all buildings:* this is the most ambitious of all options and would allow a full coverage of the building stock with EPCs. The massive roll-out of EPCs could be facilitated by existing digital and on-line tools that allow building-owners to self-assess energy performance, which could allow this option to be fee-free for the obligated parties (building owners). However, trade-offs exist between high quality of EPCs, increased information in EPCs and low-fees.
- *Require EPC in case of contract renewal with existing tenants (residential and non-residential)*
- *Require EPC for major renovation*
- *Require EPC for renovated building elements*
- *Require EPC for technical building system changes*
- *Require EPC for financial support*: the idea is that an EPC would be required once homeowners ask for financial support. To some extent this aspect is already

covered in the existing Art. 10 of the EPBD. Making a stronger the link between financial support and EPCs will increase the coverage of EPCs.

Some additional ideas were raised at a workshop with FP7 research projects focusing on EPCs in April 2021, regarding the additional and complementary use of EPC to raise awareness of buildings occupants and the supporting actions needed:

- Utility companies with access to data from district heating and electricity (smart meter) could alert owners if they use more energy than expected;
- Marketing campaign needed - most citizens do not know about EPCs;
- Optimal renovation times occur at certain points in the buildings lifetime, this could be a trigger to require to issue an EPC;
- Support financially that building owners receive a building renovation passport, issuance of an EPC as a complementary tool.
- Trigger point when people inherit a building, but rather building renovation passport than EPC.

2.2.3 Policy options for new indicators in the EPCs

The following aspects are being taken into account for new indicators in the EPCs:

Indicators that:

- bring valuable information to homeowners and buyers
- that are possible to implement
- that gives buyers a better idea of energy needs
- links energy efficiency and climate footprint

Additional indicators might increase the cost and complexity which could be affecting user acceptance and degree of comprehension/ usefulness, therefore only the necessary indicators for reaching the targets should be made mandatory. Too many indicators would make the EPC more complex and possibly more difficult to communicate.

2.2.4 Operational GHG

Including an indicator of GHG during the operational phase of the buildings would increase the awareness about the building’s carbon footprint; this is already possible now and is planned or implemented in several Member States, such as Germany and France. According to a CA EPBD report in May 2021, 16 MS have included operational carbon in EPCs on a mandatory or voluntary basis.

Including CO_2-emissions in EPCs could better demonstrate the fulfilment and achievement of targets according for the reduction of greenhouse gas emissions. Space heating is the main source of CO_2-emissions in buildings, and it varies strongly across countries, owing to both differences in heating demand (climate and building quality) and the heating fuels used.

The CO_2-emissions of a building are as important to consider as its energy consumption. Similarly, CO_2-emissions should be considered whether they occur outside or inside the building perimeter (district heating or electricity generation, vs gas boiler).

In Germany, it is mandatory to include CO_2-emissions in the EPC for information purposes, expressed in CO_2 per square meter and year. As in most other MS, the building codes do not include regulations on the level of allowed CO_2-emissions. The Building Energy Act contains conversion factors for fossil fuels, biogenic fuels, electricity and district heating and cooling. For electricity, the emission factor for electricity contains one network related factor which is 560 g CO_2 per kWh, the emission factor for renewable energy generated close to the building from photovoltaics or wind power is 0, and a displacement mix for CHP which is 860 g CO_2 per kWh.

The following table provides some examples.

Table G.8: Example of conversion factors from the German Building Energy Act

Number	Category	Energy Source	emission factor (g CO2-Äquivalent/kWh)
1	Fossil Fuels	Heating oil	310
2		Natural gas	240
3		Liquid gas	270
4		Hard coal	400
5		Brown coal	430
6	Biogenic Fuels	Biogas	140
7		Bio oil	210
8		Wood	20
9	Electricity	network related	560
10		generated close to the building (from photovoltaics or wind power)	0
11		Displacement mix for CHP	860
12	Warmth, cold	Geothermal energy, Solar thermal energy, ambient heat	0
13		Earth cold, ambient cold	0
14		Waste heat	40
15		Heat from CHP, integrated into the building or close to the building.	According to procedure B according to DIN V 18599-9:2018-09 section 5.2.5 or DIN V 18599-9:2018-09 section 5.3.5.1
16	Municipal waste		20

The German Building Energy Act includes an Innovation clause with the following content:

- Fulfilment of the main requirements of the law not through the annual primary energy requirement, but through a limitation of greenhouse gas emissions.
- New construction: equivalent limitation of greenhouse gas emissions and compliance with the final energy requirement, which does not exceed 0.75 times the annual final energy requirement of a reference building (residential and non-residential buildings)
- Renovation: equivalent limitation of greenhouse gas emissions and that of the maximum value of the final energy demand, which does not exceed 1.4 times the year-end energy demand of a reference building (residential and non-residential buildings)
- the specific transmission heat loss related to the heat-transferring surrounding area of a residential building to be constructed must not exceed 1.2 times the corresponding value of a reference building and a non-residential building to be constructed 1.25 times the maximum values of the mean heat transfer coefficient of the heat-transferring surrounding area.
- With this innovation clause, experience with a changed system of requirements is to be gathered.

BE Wallonia is an example of a MS where the EPC includes a CO_2 -indicator. It is used only for information purposes, there are no requirements in the building codes as regards CO_2-emissions. The calculations are based on emissions from heating, cooling, domestic hot water and appliances and can be compensated by emissions savings from using photovoltaics or co-generation. The calculation is made on a monthly basis and then summarised for the year (because of differences in heating and cooling needs over the year). The CO_2-emissions for heating is calculated using a CO_2-factor in kg/MJ and a conversion factor between net caloric value and gross caloric value.

In the EPC the yearly CO_2-emissions are indicated, as a total and per square meter. There is also an information included in the EPC that 1 000 kg CO_2 corresponds to driving a specific distance on diesel, petrol or travelling by plane.

Figure G.6

1 000 kg de CO_2 équivalent à rouler 8 400 km en diesel (4,5 l aux 100 km) ou essence (5 l aux 100 km) ou encore à un aller-retour Bruxelles-Lisbonne en avion (par passager).

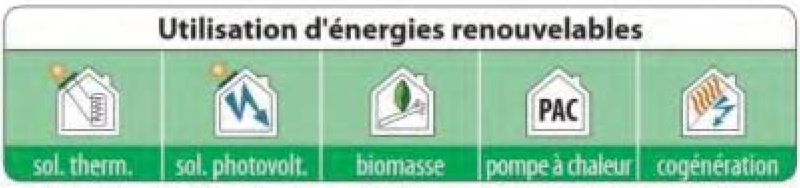
Another example is Hungary which also includes a CO_2 –indicator in the EPC. In order to calculate the CO_2-emissions from district heating, the following aspects are taken into accounts: the heat loss of the district heating network, the specific primary energy conversion factors of the various district heating producing technologies, the specific values of CO_2-emissions of primary energy sources and power system, the share of RES of primary energy sources. In average, CO_2-emissions of district heating in Hungary, with about 20% share of RES and 45% share of CHP is 46 kg/GJ. Hungary is planning to introduce threshold limits for CO_2-emissions for new buildings. For the assessment of CO_2-emissions from district heating and CHP, studies show that a thorough impact of the effects of energy efficiency measures based on real national data Member State by Member State – and not on average values – is needed[101].

2.2.5 Renewable energy sources

Although not being mandatory to include, several MS include it in the EPCs. It is necessary to take into account renewable energy in the calculation of the energy performance of the buildings.

BE, Wallonia includes RES in the EPC in the form of a graphic:

Figure G.7



2.2.6 Indoor Environmental Quality (IEQ)

A great number of scientific studies show that indoor environmental quality (IEQ) has a direct effect on health, comfort, wellbeing and productivity. Considering that people spend approximately 90% of their time indoors, it is crucial that building legislation ensures adequate levels of IEQ to promote healthy and comfortable indoor environments. Indoor air quality, thermal and acoustic comfort and sufficient levels of daylight are the major determinants of IEQ, and play an important role in ensuring the quality of life and general wellbeing of building occupants.

The main elements and impacts of IEQ are[102]:

- **Indoor air quality (IAQ)** refers to the air quality within buildings and structures. A space with good indoor air quality is low in contaminants and odours and has reasonable levels of CO2 and moisture. The restriction and control of indoor air pollutant sources, in combination with adequate ventilation, are critical in ensuring good indoor air quality [2] [3].
- **Thermal comfort** refers to the individuals' perception of the thermal environment; they should feel neither too hot nor too cold [4].

[101] https://doi.org/10.1016/j.rser.2020.110299
[102] BPIE 2018, Linking indoor environmental quality and energy performance in building regulation.

- **Daylight and artificial lighting** should provide enough illumination to enable building users to do their tasks safely and comfortably, without interference from glare and shadows [5].
- **Acoustic comfort** includes the capacity to protect building occupants from noise and provide a suitable acoustic environment to fulfil the purposes that the building is designed for

One of the reasons for proposing to include indoor environmental quality in the EPC is that the 2016 evaluation concluded that the EPBD could do more to improve the quality of the indoor environment[103]. Although ensuring adequate levels of indoor air quality, thermal comfort, lighting and acoustics within buildings are among the most potent drivers for renovation, they are rarely covered by EPCs. Indicators of comfort would enable assessment of the levels of comfort in terms of indoor environmental quality for a specific building through reliable and evidence-based inputs.

The EPBD requires energy performance to take indoor climate into account, but leaves to EU Member States the way to regulate and ensure that the improvement of the energy performance of buildings adequately takes into account and efficiently implement indoor environment quality (i.e. indoor air quality, thermal comfort, noise and lighting) and ventilation requirements at national level. However, gaps in the national regulatory framework can be observed, in particular for existing buildings where health-based mandatory minimum IEQ requirements can hardly be found in national/regional building codes.

It is essential that meeting minimum energy performance requirements and achieving the required level of indoor environmental quality (IEQ) receive the same level of attention and are mutually and consistently reinforced in plans and actions of EU Member States for renovating the European building stock. Renovation can improve indoor environmental quality, but attention is needed to avoid that more airtight and less glazed buildings deteriorate the indoor environmental quality.

Indoor Environmental Quality (IEQ) is proposed to be a voluntary indicator because there are no harmonised calculation methodologies or mandatory IEQ requirements across Member States.

Some existing EPC schemes incorporate requirements for minimum fresh air rates and protection thresholds for concentrations of indoor air pollutants, offering aspects to replicate. EPCs have the potential to become effective instruments by not only tracking the energy performance of a building but also characterising its overall IEQ through evidence-based information. An important driver of healthy buildings is sustainable commercial building certification systems which support the provision of health and wellbeing at different levels, favouring the indoor environment, ecology, socio-cultural

[103] SWD(2016) 409 final.

aspects, active and healthy lifestyles, and safety. Certifications for certain commercial and municipal new buildings includes IEQ. Level(s) includes health and comfort among its target areas and uses indicators for indoor air quality, and thermal, acoustic and lighting comfort.

To address the need for benchmarking IEQ in buildings, an index has been proposed within the framework of ALDREN[104]. The index is used to document IEQ in a building before and after renovation. The index is called ALDREN-TAIL, in short TAIL. It embraces four major components of IEQ, namely:

- thermal environment (T),
- acoustic environment (A),
- indoor air quality (I),
- luminous (visual) environment (L).

2.2.7 SRI indicator

The SRI is intended to raise awareness about the benefits of smart buildings, including energy efficiency, optimised mix of various energy sources, grid flexibility and user occupancy experience and wellbeing. A well-coordinated implementation of the two instruments, EPC and SRI, will allow for complementarity of the information provided.

In particular, the demand-side flexibility indicator of the SRI would allow the buyer to assess if the building can be managed proactively to participate in the energy market. Adding a reference to the existence of an SRI assessment in EPCs will also increase awareness and visibility of the SRI. It could also possibly ease the compilation of both the EPC and the SRI by drawing on common data. The ALDREN project is working on the possible integration and presentation of the SRI in EPC schemes.

2.2.8 Electric vehicle charging points

The availability of recharging for e-vehicles is an important information for users and investors and it is needed for policymakers as there is a lack of data on the number of recharging points in private buildings. (The reporting obligations under AFID covers mainly publicly available infrastructure and during the revision of the AFID a lack of data for recharging stations in residential and non-residential buildings was identified. According to CA EPBD, 5 MS have included electric vehicle charging points in their EPCs.

[104] The importance of indoor air quality: ALDREN TAIL | ALDREN

2.2.9 Embedded carbon

Several MS including France, Denmark, Finland, the Netherlands, Ireland and Sweden have already introduced or are planning to introduce lifecycle GHG in building regulations. There are also several private initiatives to promote sustainable construction through different certification schemes, such as from the members of the WGBC[105]. However, there are no examples of national EPC schemes including embodied carbon.

Some stakeholders have suggested that EPC should include lifecycle GHG and that the recommendations should include measures to reduce lifecycle GHG. Other stakeholders have warned against overloading the EPC with information which would make it complex and expensive.

Due to the different situation in MS related to the availability of data for performing lifecycle-analysis it is proposed that lifecycle GHG is considered mainly in the definition for new construction (see Annex H) instead of in the EPC. In the EPC the policy option being considered is to include a reference to if an LCA-calculation has been made or not (yes or no) or similar, with the possibility of providing links to where more information can be found.

2.2.10 Historical and actual energy use, total energy use

History and likely outlook of actual energy use would give a better indication of the evolution of the energy needs of the building. Total energy use can be easily calculated and included in EPCs in addition to energy use per m_2. Stakeholders have stressed that since EPCs need to provide information that is relevant for the user, total energy is a relevant indicator because of its link to annual energy costs. A common point mentioned by several stakeholders is the fact that the certificate presents estimated energy consumption (asset rating) which frequently is different from the actual energy use (operational rating). This is caused by the fact that for the estimated energy use a typical consumption profile is used, which is makes the result behaviour-independent. However, the discrepancies are also caused by lack of quality of the national energy performance calculation methodologies in some cases.

2.2.11 Other indicators

Other indicators that have been suggested by stakeholders are energy use per inhabitant, energy storage, power demand of the building, e-vehicle charging points, accessibility, asbestos, fire safety, seismic aspects. The list could be made even longer, and different aspects are important for different stakeholders and different MS depending on for instance building stock characteristics, climate zone and related legislation. It is therefore important to allow MS to complement the mandatory indicators with indicators that are necessary in their country. There are also trade-offs between the quality and

[105] World Green Building Council, www.worldgbc.org

completeness of EPCs and their costs and competences necessary for assessors to be able to issue EPCs. It is also important to keep the number of mandatory indicators to a minimum and only use those that are necessary and justified for reaching the EU targets and are within the scope of the EPBD.

2.2.12 Improve EPC recommendations

All EPCs include as mandatory element a recommendation section to provide tailor-made advice on how to improve the energy performance of buildings. The majority of EPCs feature recommendations like this ranging from no-cost measures, like changing behaviour, to medium- and high-cost measures, like enforcing thermal insulation or changing service systems. Individual renovation recommendations are provided for domestic buildings and commercial establishments in countries like the UK, Austria and Denmark as additional advice accompanying the EPC reports.

In most cases, standardised recommendations are provided to reduce the cost of a customised approach. The EPCs themselves have not been effective in driving renovations. Cost and time constraints often result in EPCs containing poorly tailored recommendations. Evidence suggests that an on-site visit, including the chance for the user to interact with the expert, influences the perceived quality and reliability of the recommendations and the chance that they will be implemented[106].

The following assessment of the EPC recommendations was made in the 2016 evaluation: "After several years of implementation, the contribution of the EPC recommendations towards stimulating renovation is limited. The global economic context is certainly a limiting factor but some respondents to the public consultation challenge any causality between the recommendations that are provided in EPCs and action taken to upgrade the energy efficiency of buildings. This is backed-up by studies bringing evidence that EPC recommendations had a weak influence, especially pre-purchase. While it is required by Article 11 that EPCs must include recommendations for the cost-optimal or cost-effective improvement of the energy performance of a building or building unit, and although most Member States have this in place in legislation, little evidence exist today of whether these recommendations actually lead to increased renovation rates as intended. This could be due to "*lack of requirements for reporting potential measures that has been done due to the recommendations, or it could be due to the absence of appropriate accompanying measures and limited trust in the certificates in some Member States, which leads to little attention being paid to the recommendations included in the certificates."*

The evaluation also stated that "Certification is sometimes seen as an administrative burden, and there is limited willingness to pay higher prices for high quality EPCs and it is generally agreed that the reliability of EPCs must be significantly improved. In

[106] X-tendo project.

particular, concerns were expressed, although not fully grounded by evidence, with the quality and possible benefits of systematic recommendations, when compared to their costs. Today EPCs for single family houses/apartment are typically sold for 85-140€, but lower prices below 50€ are also observed on the market. Such prices hardly leave the time to provide tailor made recommendation that could be trusted and taken up by building owners."

- During a workshop with EPC projects in April 2021 the following ideas were raised for improving recommendations in the EPCs: Adding costs, adopt a standardised approach, link the recommendations to goals of the national long term renovation strategies.
- Link the recommendations to BRP and the building logbook[107].

A specific area that could be improved in the recommendation is the buildings' readiness for alternative heating systems. For instance, to assess the feasibility of replacing a gas condensing boiler with a heat pump requires some additional technical information such as the peak heat demand, the availability of a heating distribution system in the building, the availability of mechanical ventilation for exhaust air heat recovery etc. The recommendation could include a checklist of the readiness to change heating system.

Some other stakeholders have suggested to relax the requirements on measures being cost-effective and focus more on the energy savings that the measures can provide.

2.3 Enhance the role of EPCs as digital tools

Table G.9: Overview of policy options C1 on enhancing the role of EPCs as digital tools

C1. Enhance the role of EPCs as digital tools			
No.	Policy action - general	Timeline	Sub-options
EPCD1	Mandatory national EPC databases	MS to implement by 2025	• Open access at least for rented properties (in line with GDPR rules), • Benchmarking capabilities
EPCD2	Mandatory national EPC databases + Reporting	MS to implement by 2025	As in EPCD1 + • Regular reporting to EC from EPC databases • Mandatory public reporting from EPC databases
EPCD3	Mandatory national EPC databases + Reporting + Link with other databases	MS to implement by 2025	As in EPCD2 + • Mandatory regular information transfer from national EPC databases to Building Stock Observatory (BSO) with common template

107 Regarding the logbook it was also observed that while EPC gives a picture of the building at a certain time, the logbook can be updated. Data in the logbook could be reused for the EPC. Standardised approach to logbooks is needed. The final output should be easy to understand. Today more stakeholders than before are interested in the results.

No.	Policy action - general	Timeline	Sub-options
			• Link EPC to other digital databases with building information

2.3.1 Why is it necessary to enhance the role of EPCs as digital tools?

Due to the diversity and disaggregation of the buildings sector, it remains challenging to acquire good data on building characteristics, energy use, and financial implications of renovation in terms of cost savings or asset values. This lack of data has negative consequences on the market perception of the cost-effective energy saving potential of the EU building stock, on enforcement tracking, on monitoring and evaluation. EPC registers/databases can be a key instrument for reinforced compliance, improve the knowledge on the building stock and better inform policy makers and support the decisions of market players.

2.3.2 Current provisions on EPC databases

As regards the EU legal provisions related to EPC databases, the EPBD does not include a requirement for MS to implement EPC databases. The EPBD does stipulate the main functions of EPC databases:

1- "Databases for energy performance certificates shall allow data to be gathered on the measured or calculated energy consumption of the buildings covered (...)
2- "Least aggregated anonymised data compliant with Union and national data protection requirements shall be made available on request for statistical and research purposes and to the building owner."

While it is not compulsory under EU legislation to establish a centralised EPC register, almost all Member States have gone beyond the obligations and have set up systems to collect EPC data at national and regional level. In most cases, the main motivation for creation of the EPC register, beside buildings data collection per se, was to support the quality control of the energy certification processes required by the EPBD, Article 18. A system of data collection can be created at national or regional level according to the country specific administrative organisation. In 2005 some regions of Austria set up the firsts EPC register and by 2014 the number of MS that introduced EPC register increased to 24[108]. As of June 2021 all MS have some sort of EPC register. However, this EPC register may not be centralised. This is particularly the case for MS where the EPC scheme has an important regional component.

As remarked by REQUEST2ACTION[109] investigation, lack of guidance on design and implementation of EPC registers resulted in a large variety of data available in the registers across Europe. The main differences are related to: databases format, data

[108] Source: D2_6.pdf; ALDEREN project
[109] https://www.buildup.eu/en/explore/links/request2action-project-6

upload method, data accessibility and functionalities of EPC databases and also development of EPC databases distinct per building typology. The tables below provide an overview on existing EPC databases data and characteristics available at the moment in selected EU countries.

The CA-EPBD has collected some information on the type of information contained in EPC databases:

- 28 databases store different inputs of data related to the EPC
- 11 databases perform the calculation of the EPC inside and register the EPC
- 19 databases are capable of generating an EPC based on the information collected in the database
- 2 databases collect only a copied version of the EPC (but no data)

In all cases, the EPC database should retain the underlying EPC data, making it easier to access the building information and to perform verification and quality checks. In order to do so, the EPC database should store the full information required to produce information for a given building (allowing for replication of the EPC).

Responsibility for storing the EPCs also varies across Europe. Some countries have centralised national databases, while others have regional databases (e.g. Italy, Austria), and/or additional national databases with more limited content than the regional ones.

Figure G.7: Type of data collected in the databases for EPCs – Awaiting approval from the CA EPBD for publication.[110]

[110] Concerted Action EPBD: https://epbd-ca.eu/. Based on information provided by Member States.

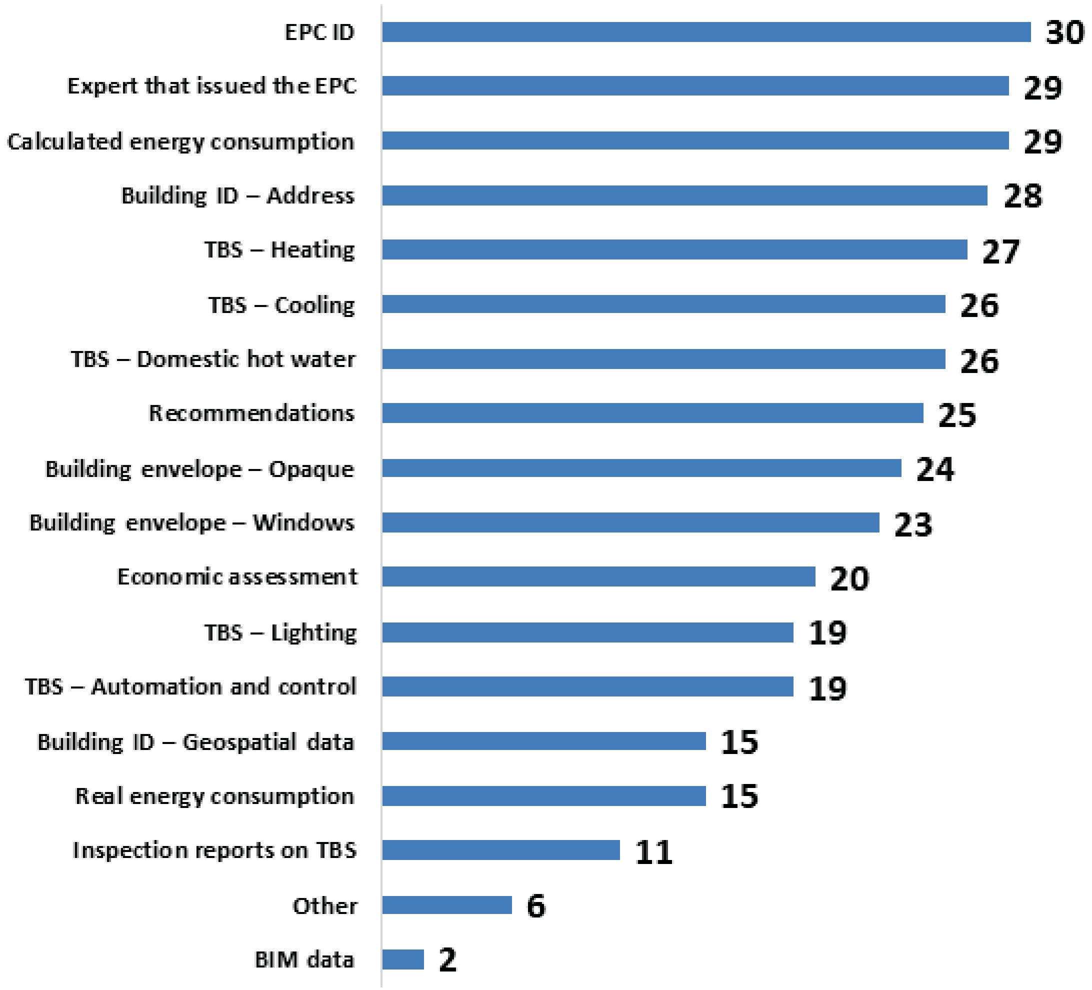


Table G.10: Number of variables and size of EPC databases – Awaiting approval from the CA EPBD for publication.[111]

Member State	Average # of variables per EPC		EPC DB size (in GB)	Size per EPC (in kB)
	Residential	Non-residential		
Austria	500	600	5	52
Belgium - BR	200	---	130	592
Belgium - FL	750	750	950	550
Belgium - WL	400	---	1.300	2.363
Bulgaria	221	221	14	1.881
Denmark	240	240	2.000	3.322
Estonia	---	---	430	14.903
Finland	80	80	64	580
Greece	95	190	2	2
Ireland	70	---	935	1.134

[111] Concerted Action EPBD: https://epbd-ca.eu/. Based on information provided by Member States.

Member State	Average # of variables per EPC		EPC DB size (in GB)	Size per EPC (in kB)
	Residential	Non-residential		
Italy	100	100	81	77
Lithuania	123	123	0	1
Luxembourg	165	---	---	---
Malta	100	100	---	---
Netherlands	150	150	2	0
Portugal	250	300	3.500	2.191
Rep. of Cyprus	31	31	1	13
Romania	30	30	600	629
Slovakia	168	210	2	18
Slovenia	70	80	99	1.483
Spain	150	180	---	---
Sweden	200	200	196	294

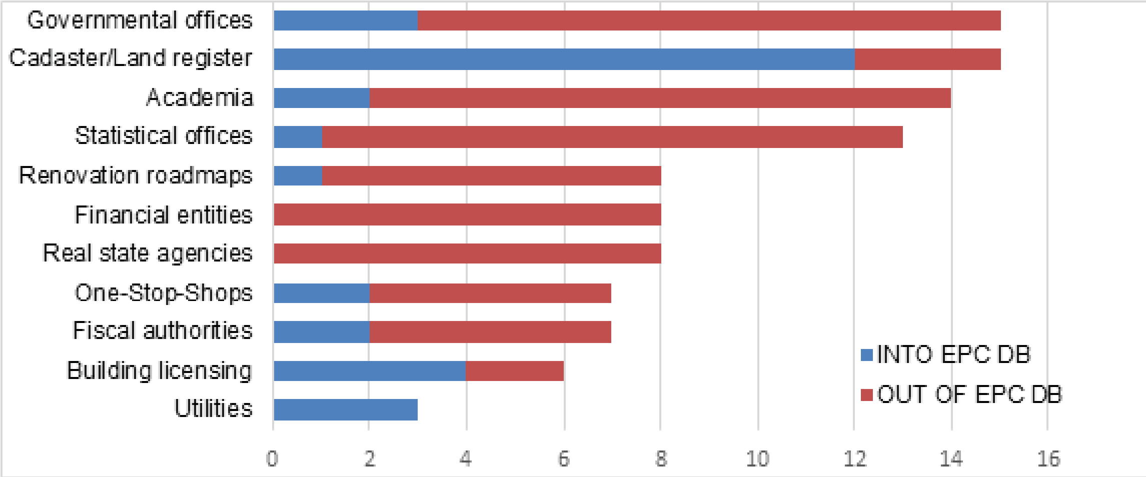
In this context, EPC databases can play a major role in the quality assurance of the EPC scheme. This is particularly important because if the data is made available for the public and/or used for other purposes (including policy design), it has to be reliable and trustworthy.

The information from the EPC databases can be shared with other databases. This has the benefit of allowing for the information contained in it to be cross checked. For example, building area can be compared with information in the Land register (to detect errors).

The general public can access many of the databases available, but sometimes the access is limited for special groups like energy advisors etc. The ways to access databases are also different across the countries. Sometimes inserting the street plus housing number is sufficient (e.g. Sweden), while sometimes the complete EPC identification number needs to be provided (e.g. Ireland). Furthermore, the amount of data accessible from a public database is different. In some of the countries a full EPC along with the recommendations can be accessed, while in the others, the publicly available information is limited to key values, such as EPC rating class, energy consumption and the full EPC is only available for the building owner (like in the Netherlands).

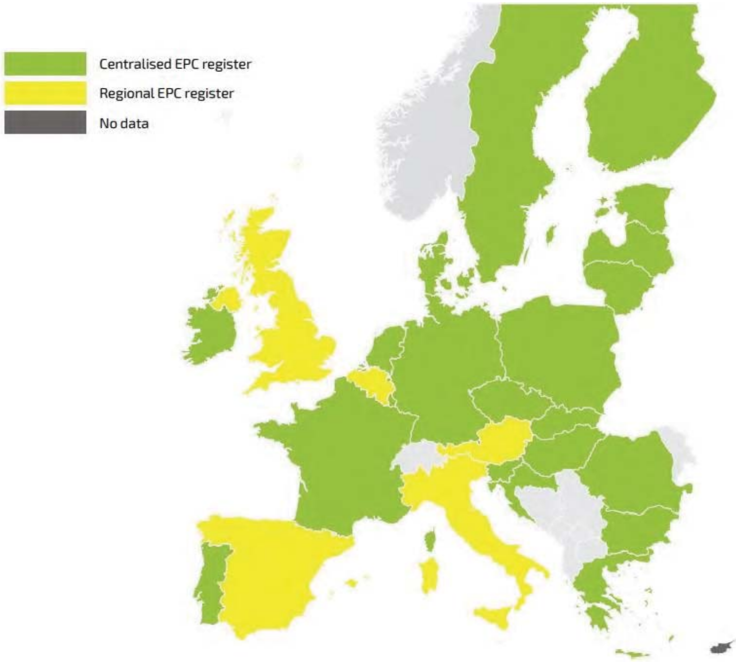
Figure G.8: Interoperability – Type of DB/service connected and main flow of data (in our out) for different MS[112]

[112] Concerted Action EPBD: https://epbd-ca.eu/. Based on information provided by Member States.



A key element since 2018 is the introduction of the General Data Protection Regulation (GDPR), which regulates data protection and data privacy. The entry into force of the GDPR has caused a general decrease in the level of available information as public bodies were in the process of clarifying the legal basis. A legal requirement to store EPC information and develop EPC databases would facilitate the gathering and sharing of information related to building energy performance (Article 6 of GDPR).

Figure G.9: Overview on existing EPC database in EU countries and UK and of the data e collected in the EPC database register



EPC databases offer opportunities to leverage the instrument's impact and perceived usefulness. Some Member States (e.g. Bulgaria, Germany, Greece and Finland) have EPC registers that store the input data used to calculate the EPC result, while others (e.g. Denmark, Estonia, Ireland, Netherlands, Portugal) have made the data publicly available. Denmark made its database public in 1997 and the breadth, quality and accessibility of the Danish EPC database set an example to other countries and regions. These more advanced national registers also allow for improved quality control of EPCs, as well as statistical analyses of the building stock.

Figure G.10: Examples of information contained in EPC and EPC databases[113]

	General building information	Energy performance data	Current EPC rating	Potential EPC rating	Indoor environmental quality
Austria	★	★	★		
Belgium, Flanders	★	★	★	★	
Denmark	★	★	★	★	
Estonia	★	★	★		
Greece	★	★	★		★
Italy	★	★	★		
Poland	★	★	★		
Portugal	★	★	★	★	★
Romania	★	★	★	★	
Scotland	★	★	★		
Germany	★				
Ireland	★	★	★	★	
France	★	★	★		
England and Wales	★	★	★		
Spain	★	★	★		
Sweden	★	★	★		

2.3.3 Policy options to enhance the role of EPCs as digital tools

It is acknowledged that high quality data on the building stock is needed, and that this data could be partially generated by EPC registers/databases that practically all Member States are developing and managing.

BPIE concluded that strengthening energy performance certificates could create multiple benefits. In implementing the EPBD, EU Member States have established national EPC schemes. Improved and better-aligned EPCs could be beneficial to many strategic areas.

[113] X-tendo project.

They could include information on the carbon performance and provide information on renovation costs and thereby help to better capture trigger points. They could also be a dynamic data repository once digitalised, online and accessible, and prove compliance with policies (e.g. with mandatory minimum performance requirements; proof of eligibility for financial support, etc.)[114].

The abovementioned study also concludes that available digital technology should be rolled out to enable promising approaches to support the creation of a sustainable built environment.

Digital technology development is advanced e.g. in reaping flexibility gains from the demand side, but it is not yet fully exploited for the creation of a sustainable built environment. For example, while BIM is ready to be used in constructing new buildings, it is not yet mainstream in most markets, only a few solutions exist for the renovation of existing buildings and the cost for BIM remains a barrier in some markets. New opportunities to utilise digital innovations to decarbonise the existing building stock are still not fully explored, due to path-dependency or the remaining profitability of traditional practices. Better data collection and the use of digital solutions (e.g. making use of blockchain technology, digital building logbooks, or at least improved and web-accessible EPC databases) can steer the reorganisation and optimisation of construction and renovation processes. The availability of robust data enables new business models and better-targeted building renovation policies. Subsequently, building renovation could be organised along with priority areas, compliant with long-term targets and delivered at a faster pace.

The options to strengthen the accessibility of data include that EPC databases should be mandatory. An EPC database has different potential uses, such as data mining for country/sector reports, interoperability with other databases and publication of market-relevant information, to different stakeholders: building owners, construction companies, real estate actors, public authorities, etc. In this context, the quality assurance of the EPC databases can contribute significantly to improving trust in EPC data.

The main function of EPC databases is the storage of EPCs and of the underpinning data which makes these a very important source of building stock information, especially if relevant parts of the information is made available to stakeholders such as building owners, construction companies, real estate actors, public authorities etc. When dealing with the question of how the performance of EPC databases may be improved, numerous topics can be highlighted. These usually include aspects such as how to set up an EPC database, how to gather the data, how to establish the interoperability of different databases, and how to use data and extract relevant insights from it. Last but not least, ensuring the reliability and accuracy of the information stored in the database through quality assurance processes and data verification remains a key requirement common to

[114] BPIE, Lessons learnt study.

all EPC schemes. Current practices of setting up and operating EPC databases show significant differences among EU Member States in terms of the above requirements.

3- RELEVANT EU-FUNDED RESEARCH, INNOVATION AND COORDINATION AND SUPPORT ACTION PROJECTS ADDRESSING IMPROVEMENTS TO EPCS.

1. **U-CERT (2019-2022)** aims to introduce a next generation of user-centred Energy Performance Assessment and Certification Scheme that includes new indicators for asset rating, operational rating and smart readiness, allowing to value buildings in a holistic manner. The scheme is based on CEN standards and supported by an EU-wide training and certification process for building professionals. Moreover, the project wants to encourage innovative solutions, including the SRI, and support end-users in decision-making, e.g. with a view to deep renovation. https://u-certproject.eu/

2. **X-tendo (2019-2022)** aims to support public authorities in the transition to a next-generation of EPC-schemes. In this, the project creates a knowledge hub with innovative EPC features. These features are for example innovative technical elements for the EPC assessment methodologies; new indicators, such as Smart Readiness, Comfort, Outdoor Air Pollution, Real Energy Consumption, District Energy; and approaches to maximise the value of EPC data, e.g. by collecting and using them in EPC Databases, Building Logbooks, as part of Financing Options and Offers and for One-stop-shops. https://x-tendo.eu/

3. **QualDeEPC (2019-2022)** aims to enhance the quality and cross-EU convergence of Energy Performance Certificate schemes, and to strengthen the link between EPCs and deep renovation. In this, the project will work on EU-wide convergence of the building assessment and the issuance, design, and use of quality-enhanced EPCs as well as on the consistency of the recommendations for building renovation. A key corner stone in this strategy is the QualDeEPC Network, a "Community of Interest", gathering experienced practitioners, researchers and standardisers from the national and EU-level. https://qualdeepc.eu/

4. **BuiltHub (2020-2024)** aims to put in place a robust web-based platform that allows for collecting and extracting building performance and characteristics related data, with the overall objective to map and characterise the EU building stock. In this, the platform will complement existing repositories, such as the EU Building Stock Observatory, and will offer a hub for an active community of data users. The platform will be based on a standardised building data management approach. One important rationale of the platform is to contribute to the design of more effective renovation programmes. https://builthub.eu

5. **D^2EPC (2020-2023)** aims to develop a calculation methodology for a novel set of energy, environmental, financial and human comfort/wellbeing indicators. It has a clear focus on digitalisation, large-scale data collection, development of digital twins

and SRI indicators. One of the main outputs of the project is a digital platform for issuing and updating EPCs, integrating GIS and user-centred recommendations, benchmarking/forecasting of buildings' performance and verification services. Standardisation/certification bodies as well as a member of the CA EPBD inside the consortium help to ensure the robustness of the developed approach. https://www.d2epc.eu

6. **EPC RECAST (2020-2023)** aims to develop a scheme for next generation of Energy Performance Assessment and Certification that focuses on existing residential buildings, combined with renovation roadmaps. The project pays specific attention to the needs of end-users, building owners and EPC assessors, as well as to comfort levels, and provides personalised and tailor-made recommendations on renovation options and related costs. https://epcrecast.wordpress.com/

7. **ePANACEA (2020-2023)** aims to develop a "Smart Energy Performance Assessment Platform" (SEPAP) with 3 modules: a smart and data driven energy performance tool using inverse modelling and operational data; a simplified monthly based calculation aligned to ISO52016; and an advanced hourly simulation model aligned to ISO52017. It will develop a "Decision Matrix" to assist end-users to select the appropriate module(s) for their use. The project includes five Regional Exploitation Boards covering EU27 + UK + NO. https://epanacea.eu/

8. **E-Dyce (2020-2023)** aims to develop a dynamic certification of buildings, following real time optimization of energy consumption and comfort, and linking it to renovation roadmaps. It combines smart technologies with low-tech solutions and the free running potential of buildings, which should allow to extend the scope of EPC labelling towards historical buildings and buildings in the Mediterranean that rely on natural ventilation. The project has a strong focus on end-user behavioural change and provides tenants and building operators with feedback on building performance and recommendations how to adapt behaviour to increase energy performance. https://edyce.eu/

9. **EUB SuperHub (2020-2023)** will develop a scalable methodology to view, assess and monitor buildings throughout their lifecycle, including for aspects such as embedded energy, costs etc. It will contribute to improving the certification process and promote the use of harmonised indicators in national and regional EPCs, towards allowing to better evaluate the impact of transnational policies, such as structural funds and public building renovation, in the EU. EUB SuperHub will tie the fragmented assessment and certification schemes across Member States together through a digital one-stop shop platform.

10. **CrossCERT (2021-2024)** aims to create a product testing methodology for new EPC approaches that will improve accuracy, usability and homogeneity of EPCs across Europe while ensuring people-centric designs. The project will organise cross-testing of current EPCs and new concepts among energy authorities in 10 European

countries and establish a repository of test cases. Moreover, the project provides guidelines for the training of certified EPC issuers and works towards a better integration of next-generation EPS with energy audits, logbooks and Building Renovation Passports as well as with the needs of investors and one-stop shops-initiatives. The project will engage with networks towards a better endorsement and outreach.

11. **TIMEPAC (2021-2024)** will review existing barriers in the certification process (technical, methodological, legislative) and propose improvements to existing EPC schemes, including for the links between EPC databases and other data sources, such as BIM, cadastre, socioeconomic data, BACS, etc. Moreover, it will support standardised procedures for data collection, contribute to the transformation of static EPCs into dynamic ones considering SRI-related aspects and use EPC databases and other data sources to assess the impact of building renovation scenarios. Finally, the project will provide elements to improve the training materials for professional certifiers.

12. **iBRoad2EPC** (2021-2024) builds on the results of the **iBRoad project** (2017-2020) which developed a model for the Building Renovation Passport. **iBRoad2EPC** aims to bridge the Building Renovation Passport with the EPC. In this, it will improve and expand its format and scope to consider additional features and new target groups and sectors, notably multi-family and public buildings. The project will assess the potential and practicability of merging the EPC with the Building Renovation Passport and adapt the iBRoad concept accordingly. The validity of the *iBRoad2EPC* will be tested in six countries and complemented by training programmes for energy auditors and EPC issuers.

13. **EPC4EU data model,** is a tool for the harmonisation and the interoperability of EPC (Energy Performance Certificates) databases across Europe.

14. **ALDREN** – is an EU performance rating on EPCs alongside national EPC rating. An EU energy rating for offices and hotels has been developed. Set of indicators to high-light non-energy benefits of building renovation (health and wellbeing, SRI, market value, financial risks etc.).

15. **RENOVALUE** – The project developed a training toolkit for property valuation professionals on how to factor energy efficiency and renewable energy issues into valuation practices, understand the impact of building performance and property values and advise their clients accordingly.

16. **RE-VALUE** –was a project to develop international guidance for property appraisers, incorporating the collection and easy analysis of relevant evidence. The ambition was to encourage valuers to reflect the value of energy efficiency (EE), in their valuations of social and private housing stock. REVALUE focused primarily on revising and strengthening the requirements of due diligence and reporting in relation

to the energy efficiency and sustainability characteristics of residential properties. The project included provision for the creation of targeted training material for valuers.

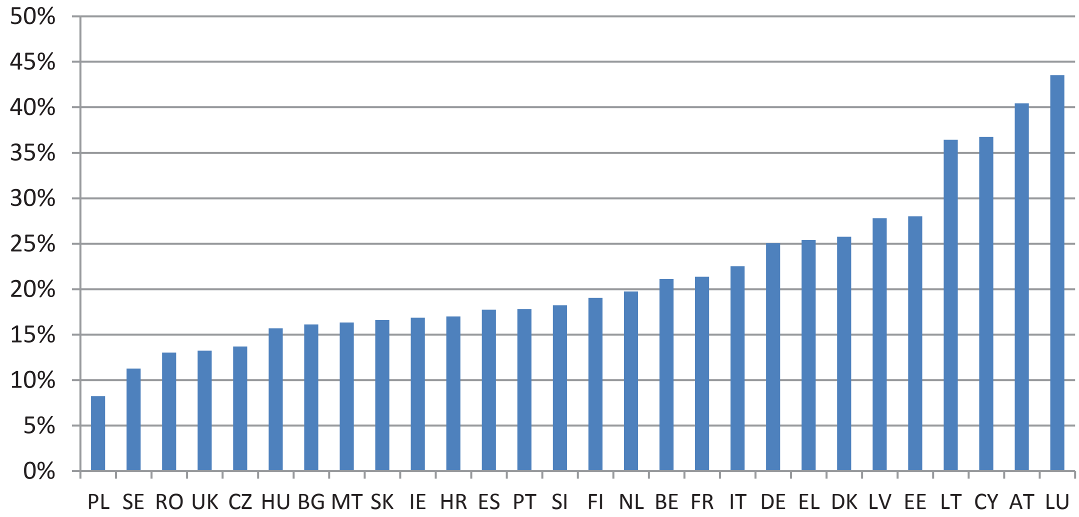
Annex H: Zero Emission Buildings

1. Overview on NZEB requirement and their current implementation in Member States

Pursuant to Article 9 of the Energy Performance of Building Directive 2010/31/EU (EPBD), all new buildings must be nearly zero-energy buildings (NZEB) since the beginning of 2021, while all new public buildings already must be NZEB since the beginning of 2019. [115]

The requirement for all new buildings to be NZEB was introduced in 2010 and aimed at the time at setting a 'future-proof' vision for the building sector and mobilise the market and stakeholders accordingly, towards a long-term vision and a higher ambition compared to the progressive tightening of the minimum energy performance requirements through the cost-optimal process.

Figure H.1: Share of NZEB in the total EU construction market, JRC[116]



[115] NZEB standards were defined by EU Member States at different points in time. Most Member States introduced the definitions well before the date of application of the NZEB obligations (2021 for all new buildings and 2019 for all new public buildings). Some Member States, ahead of the actual implementation and based on the second round of the cost-optimal calculations (in accordance with Article 5 of the EPBD), decided to amend the definitions, and some others postponed the introduction of NZEB requirements due to the COVID-19 pandemic.

[116] JRC report: Monitoring Member States progress towards Nearly Zero-Energy Buildings (NZEBs), under development.

A NZEB is defined as a building “with a very high energy performance, where the nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources produced on-site or nearby” (Article 2(2) EPBD).

While the EPBD provides the NZEB criteria that must be defined (including a numerical indicator of primary energy use expressed in kWh/m2.y), it allows a high degree of flexibility to Member States to reflect national, regional or local conditions in the national NZEB definitions, such as targets, climate, construction methods and other factors. The heterogeneity of NZEB levels also reflects different calculation methodologies for the energy performance, different cost-optimal levels and building typologies, while the treatment of on-site and off-site renewable energy and the determination of primary energy factors can also lead to significant differences.

For that reason, the definitions of NZEB significantly diverge across Member States for different building typologies. The differences relate to the metrics used, the extent to which residual energy requirements are covered by renewable energy, the establishment of additional requirements, etc. 18 Member States have defined an EPC class which is equivalent to NZEB requirements, while the NZEB definition in 16 Member States includes an obligation for a minimum share of energy demand to come from renewable sources.

While NZEB levels are a requirement for new buildings, in some Member States, the same or similar requirements are applied to the renovation of existing ones. Several Member States have in fact also defined NZEB levels for existing buildings undergoing a major renovation (with 10 Member States having exactly the same requirements for new and existing buildings).

The number of NZEBs in Europe has increased significantly in the last decade. The share of NZEB in the total construction market has increased during the period 2012-2016 in EU (from 14% in 2012 to 20% in 2016, on average). Almost 1.25 million buildings were built or renovated to NZEB (or similar) levels from 2012 to 2016, mostly residential.[117]

Besides the establishment of technical regulatory measures to define NZEBs, national policies have also been set up in several Member States to stimulate the uptake of NZEBs, through regulatory measures, followed by financial and fiscal measures. Most of the measures target the envelope and heating systems. The NZEB requirements are also well addressed in the Long-Term Renovation Strategies, in which several Member States set targets for retrofitting to NZEB levels and deep energy renovations.

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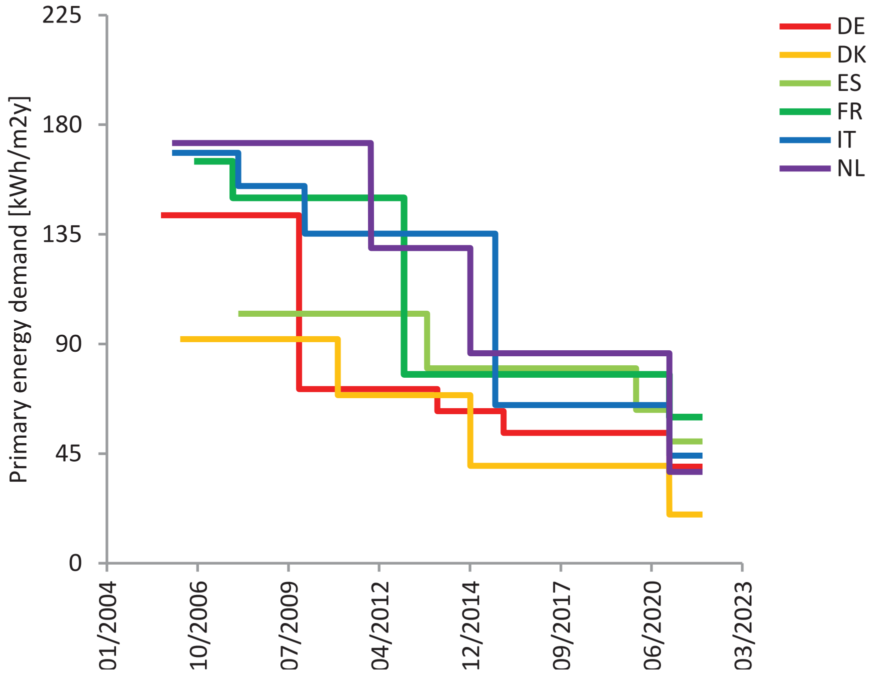
[117] Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU, 2019
https://ec.europa.eu/energy/studies_main/final_studies/comprehensive-study-building-energy-renovation-activities-and-uptake-nearly-zero-energy_en

It has been assessed that on average across the EU the current NZEB requirements are currently 70% more ambitious than the national minimum energy performance requirements for new buildings in place in 2006. This was achieved through progressive legislative steps at all levels (European, national, regional) over the last 15 years. Figure H.2 shows the main regulatory steps for some countries in terms of maximum primary energy demand for the average residential building (per type, dimension and climate).

Figure H.2: Improvement of minimum energy performance requirements for residential buildings in some Member States, since the entry in force of the EPBD[118]



The development of NZEB definitions has been often carried out by Member States in parallel with the calculation of cost-optimal levels pursuant to Article 5 of the EPBD (carried out twice, in 2013 and 2018). The cost-optimal framework allows Member States to identify the lowest total costs over a building's lifetime by comparing different energy efficiency and renewable energy measures and to define NZEB requirements accordingly. As new technologies are deployed in the market and related costs are reduced, each five-year cost-optimality cycle presents an opportunity to amend energy performance codes and close the gap to cost-optimal levels.

Table below presents an overview of the different NZEB levels based on national definitions, noting that in many cases different assumptions and estimations were applied aiming to provide a comparable framework. Indicatively, one can estimate that NZEB

[118] JRC report: Monitoring Member States progress towards Nearly Zero Energy Buildings (NZEBs), in progress.

energy performance levels vary from 20 kWh/m^2.y (Belgium Flanders) to 132 kWh/m^2.y (Estonia) in new residential buildings, and 30 kWh/m^2.y (Belgium Flanders) and 176 kWh/m^2.y (Malta) in new non-residential buildings.[119]

Table H.1: Estimations for NZEB levels per Member State based on national definitions or other sources, JRC

	NEW BUILDINGS (kWh/m^2.y)		**EXISTING BUILDINGS (kWh/m^2.y)**		**RES**	**EPC**	**Specificities**
	Residential	Non-residential	Residential	Non-residential			
AT	41	84	68				
BE-BRU	45	85	55	100			
BE-FLA	20	30	20		15 kWh/m^2.y (residential), 20 kWh/m^2.y (non-residential)		without RES share
BE-WA	85					A	
BG	43	63	43	63	55%	A+	without RES share
CY	75	94	75	94	25%	A	
CZ	80	80					
DE	40	75	65				KWh efficiency house 55/70
DK	37	51				A	
EE	132	85	157	136		A for new, C for existing	without appliances share
EL	37	92	75	138	15-60% depending on building type	A for new, B+ for existing	
ES	31	112	31	112	50%		Average of 6 different climatic zones values

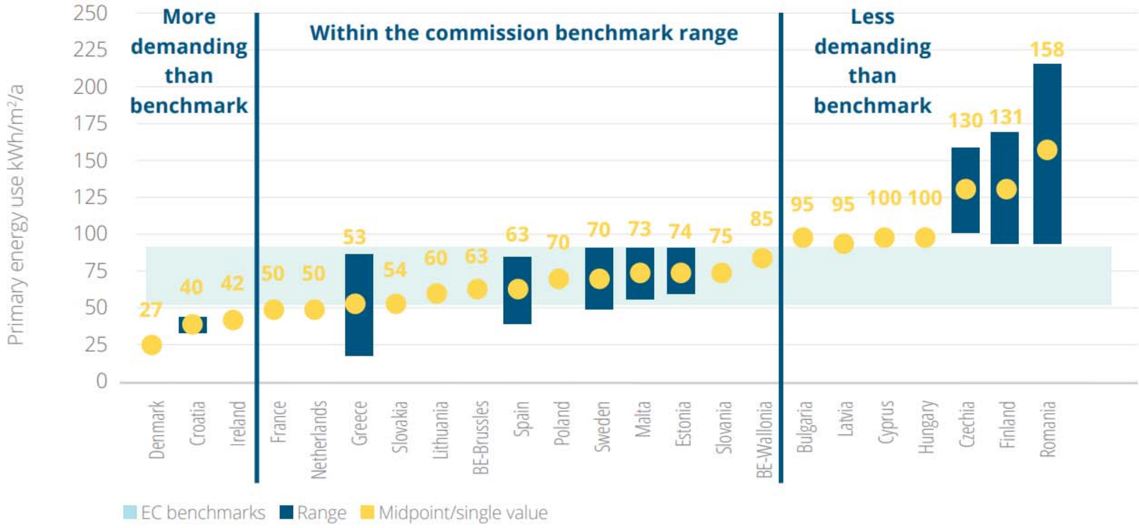
[119] JRC report: Monitoring Member States progress towards Nearly Zero Energy Buildings (NZEBs), under development. To be noted that the figures in many cases are estimated based on assumptions (e.g. averages for different building typologies and climatic zones, calculations based on reference buildings, consideration of energy uses, etc.) as the national definitions cannot be directly compared.

FI	94	85	94	85		B	Residential: Average of different types of detached houses
FR	60	110	100	150			Same as cost optimal since 2014
HR	28	21	28	21	30%	A+	Average of continental-coastal, without RES share
HU	100	90	100	90	25%	BB	Residential: without lighting, non-residential: with lighting
IE	33	35	100	99	20% (new residential)	A2 (new residential), A3 (new non-residential), B2 (existing residential)	
IT	35	117	35	117	50%		Average of 6 different climatic zones of IT
LT	60	80			50%	A++	
LU	45	60	45	60			
LV	95	95	95	95		A	
MT	56	176	56	176	25% residential 20% non-residential		Without RES share
NL	30	28			30-50%		Without RES share
PL	75	107.5	75	107.5			EP = EPH+W + ΔEPC + ΔEPL
PT	35	130	55	140	50% (residential)	A	
RO	78	40	78	40	30%		Values for the most representative climatic zone according to RO CA report Without RES share
SE	90	70				A-C	
SI	70	55	95	65	50%	A1, A2, or B1	
SK	54	61	54	61		A0	Without RES share

Source: JRC

Comparing the NZEB definitions (where possible) with the benchmark provided in the Commission's Recommendation[120] for different climate zones reveals that the NZEB values for energy performance (kWh/m^2.y) in most Member States exceed the recommended EU values in both residential (single family houses) and non-residential buildings (offices).

Figure H.3: Comparison of national NZEB values (kWh/m2.y) for single family houses and offices with the Commission's recommendations benchmark range, BPIE[121]



[120] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016H1318&from=EN

[121] BPIE, 2021: Nearly Zero: a review of EU Member State implementation of new build requirements https://www.bpie.eu/wp-content/uploads/2021/06/Nearly-zero_EU-Member-State-Review-062021_Final.pdf.pdf

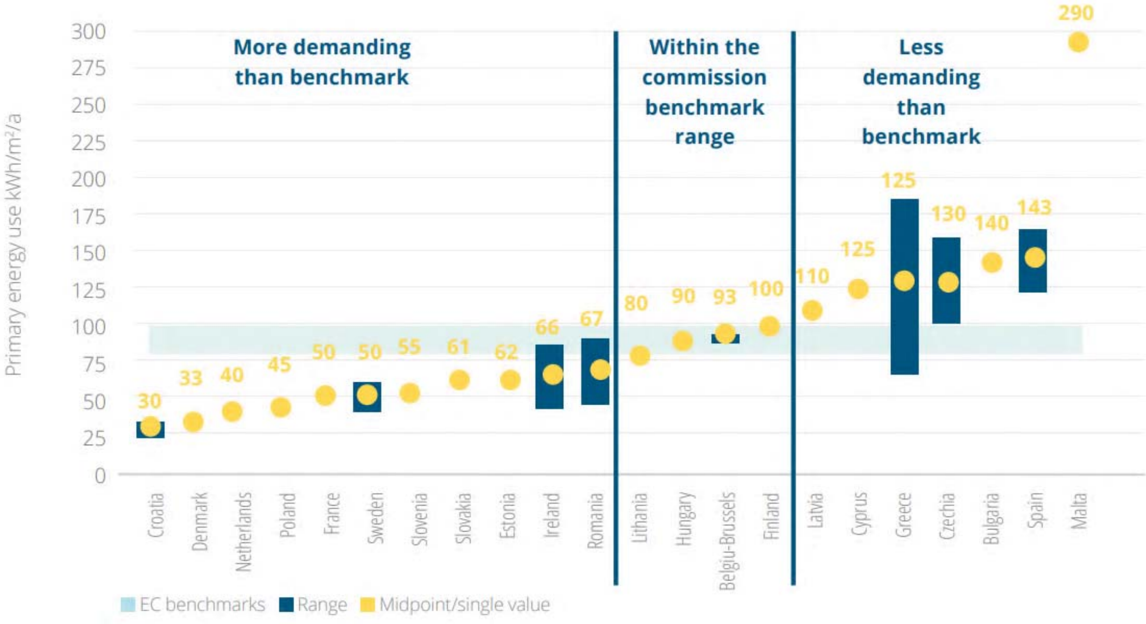
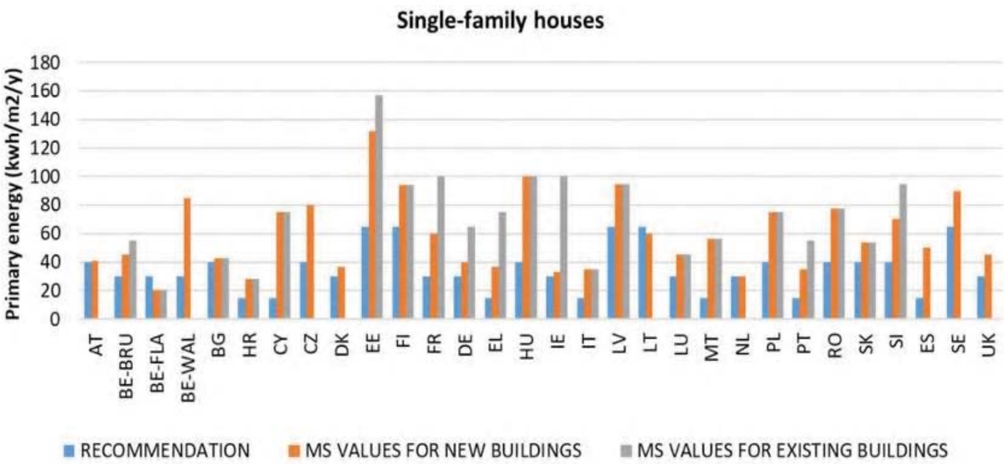


Figure H.4: Indicative comparison of the national NZEB definition for single-family houses and the values in the Commission's Recommendations, JRC[122]



Almost a decade after the establishment of the NZEB concept in the European legislative framework and several years after the establishment of the relevant national measures, the NZEB standards, which are the current construction standards for new constructions, can be reached using appropriate technologies and best practices, combining high efficient solutions to minimise the energy demand for building operation and supplying

[122] JRC report: Monitoring Member States progress towards Nearly Zero Energy Buildings (NZEBs), under development, based on national long-term renovation strategies, Concerted Action EPBD reports, clarifications by Member States and other sources. It has to be noted that many Member States do not include a specific indicator of primary energy use (in kWh/m2.y) as part of the definition of NZEB requirements, but the definition is based on minimum performance levels as compared to reference buildings.

the remaining demand to a large extent with renewables produced onsite (such as PV, solar thermal, biomass, heat pumps) together with building automation control systems (BACS).

The most implemented solutions rely on both passive (e.g. envelope insulation, solar gains, natural ventilation, daylighting, thermal mass, night cooling), and active (e.g. mechanical ventilation with heat recovery, heat pumps or district heating, BACS) measures. Indicatively, U-values[123] are found between 0.15 – 0.20 W/m²K for walls, 0.10 – 0.25 W/m²K for roofs and approximately 0.85 – 1.0 W/m²K for windows. For heating, the most widespread measures are heat pumps and district heating. The minimum contribution from renewable sources varies per Member State and presents a wide range of RES both in terms of share of RES and the technologies used. PV, heat pumps, solar thermal and biomass are the most commonly implemented technologies. In some cases, the share of renewable energy is not quantified.

As mentioned before, reaching NZEB levels is required for the construction of new buildings and in many case for existing buildings too. The analysis of different case studies developed before the actual entry into force of the NZEB requirements, showed that investment costs were on average 11% higher compared to conventional constructions[124]. However, over the last years significant cost reductions in key NZEB technologies could be observed, especially for renewable energy solutions, while in some cases they benefit from financial incentives. This will further reduce the gap. It also has to be noted that if the total life-cycle costs (including also operational energy costs) are considered, NZEBs are already cost-effective.

For instance, over the past decade, the falling costs of PVs and the competing cost of generated electricity made this technology more attractive. In 2020 over half of Europe's PV capacity was installed on buildings[125]. PVs are further expected to show the highest cost decrease, between 41% and 56% towards 2050, while the costs of solar thermal are expected to decrease between 22% and 51% towards 2050. Stationary batteries are foreseen to have a substantial cost reduction potential of around 65% until 2050. Some Member States also give incentives for the wider use of biomass boilers, which could potentially reduce their cost by 10-20% between now and 2050. The cost of heat recovery systems is also expected to decrease significantly (by 35-60%) between now and 2050.[126]

[123] The thermal transmittance (U-value) of a building element is the heat flow rate in a steady state divided by area and by the temperature difference between the surroundings on each side of a system. The units of measurement are W/m²K.
[124] https://epbd-ca.eu/wp-content/uploads/2018/04/CA-EPBD-CT1-New-buildings-NZEBs.pdf
[125] International Energy Agency, 2020 https://www.iea.org/reports/renewables-2020/solar-pv
[126] JRC report: Monitoring Member States progress towards Nearly Zero Energy Buildings (NZEBs), under development.

The concept of NZEB has also developed and has been applied in pilot projects at district level, shifting the focus from the single building to the district scale, creating Net Zero-Energy District (NZED).[127]

The concept of NZEB has received support by 84% of the respondents to the public consultation. However, many stakeholders pointed out that the current definitions of NZEBs are not ambitious enough to contribute towards a fully decarbonised building stock. In addition, definitions need to be harmonised across EU Member States.

Stakeholders also raised the issue of future updates of the NZEB definition and its interplay with zero emission buildings. Some argue that the NZEB definition should be replaced with a definition of energy positive buildings, which should be based on energy demand and focus on life-cycle emissions performance, indicate a minimum share of renewable energy and make a link with EPC classes.

2. Definitions of Zero emission buildings

2.1. Overview of literature/international definitions

The buildings sector is a major source of greenhouse gas (GHG) emissions and one of the hard to decarbonise due to its multi-stakeholder and heterogeneous structure. To meet the longer-term climate goals, it is necessary to significantly reduce the operational energy consumption, which represents the biggest part of the GHG emissions of the current building stock, and to start addressing buildings' full life cycle GHG emissions.

The concepts of low-energy and low-carbon buildings have been comprehensively addressed over the last decades and several low-energy and low-carbon definitions and concepts have been developed and applied worldwide.

Table H.2: Low-energy and low-emission buildings definitions around the world (non-exhaustive list)

Name	Definition	Region
Nearly zero-energy	A building that has a very high energy performance and the nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby	European Union

[127] For more information see (a) JRC report: Enabling Positive Energy Districts across Europe: energy efficiency couples renewable energy (2020), (b) JRC report: From nearly-zero energy buildings to net-zero energy districts (2019).

Passive house	A Passive House is a building that fulfils the following criteria: 1. The space heating energy demand ≤15 kWh/m^2/year (roughly the same for space cooling demand in warm climates) 2. Primary energy demand, total energy to be used for all domestic applications must be ≤ 60 kWh/m^2/year 3. Airtightness**,** **≤**0.6 air changes per hour at 50 Pa pressure both outwards and inwards 4**.** Thermal comfort must be met for all living areas during winter as well as in summer, with not more than 10 % of the hours in a given year over 25 °C	Developed by Passivhous Institut[128], now international with some variations
Zero carbon ready	A zero- carbon- ready building is highly energy efficient and either uses renewable energy directly, or uses an energy supply that will be fully decarbonised by 2050, such as electricity or district heat. This means that a zero- carbon- ready building will become a zero- carbon building by 2050, without any further changes to the building or its equipment. Zero- carbon- ready buildings should adjust to user needs and maximise the efficient and smart use of energy, materials and space to facilitate the decarbonisation of other sectors.	International Energy Agency[129]
Zero emission	A zero emission building produces enough renewable energy to compensate for the building's greenhouse gas emissions over its life span which depends on how many phases of a building's lifespan are counted in. The 5 most important definitions, in rising ambition level, are: **ZEB – O:** The building's renewable energy production compensates for greenhouse gas emissions from operation of the building. **ZEB – O + EQ:** The building's renewable energy production compensates for greenhouse gas emissions from operation of the building and the energy use for equipment (plug loads). **ZEB – OM:** The building's renewable energy production compensates for greenhouse gas emissions from operation and production of its building materials. **ZEB – COM:** The building's renewable energy	Norway, The Norwegian Research, ZEB Centre[130]

[128] https://passivehouse.com/02_informations/02_passive-house-requirements/02_passive-house-requirements.htm
[129] IEA 2020: Net Zero by 2050. A Roadmap for the Global Energy Sector
[130] http://zeb.no/index.php/en/

	production compensates for greenhouse gas emissions from construction, operation and production of building materials **ZEB – COMPLETE:** The building's renewable energy production compensates for greenhouse gas emissions from the entire lifespan of the building. Building materials – construction – operation and demolition/recycling.	
Low-emissions and positive energy	**Powerhouse Paris Proof** is a new standard based on the Paris Agreement's 1.5 degree target. The standard lists maximum and total CO2 emissions per square metre, including the construction phase, energy in operation, materials and disposal. The building follows the Futurebuilt's energy positive buildings definition and shall during its lifetime produce more energy than it uses for materials, production, operation, renovation and demolition.	Powerhouse Norway[131]
Net zero emission	The overall goal of a net zero emission building (NZEB) is that all emissions related to the energy use for operation as well as embodied emissions from materials should be offset by on-site renewable energy generation. The addition of the word "net" indicates that energy can be exported from and imported to the building, and that the net energy or emission balance is calculated over a specific period of time, usually a year. In practice, this usually means that the building is connected to the energy grid.	Good et al., 2014[132]
Zero emission house (ZEH)	A ZEH is a detached residential building that does not produce or release any CO2 or other greenhouse gases to the atmosphere as a direct or indirect result of the consumption and utilisation of energy in the house or on the site	Australia[133]

[131] https://www.powerhouse.no/en/what-defines-the-powerhouse-standard/
[132] Good, C., Georges, L., Kristjansdottir, T., Houlihan Wiberg, A., Hestnes, A.G., 2015. A Comparative Study of Different PV Installations for a Norwegian NZEB Concept, in: Proceedings of the EuroSun 2014 Conference. Presented at the EuroSun 2014, International Solar Energy Society, Aix-les-Bains, France, pp. 1–10. https://doi.org/10.18086/eurosun.2014.20.03
[133] Riedy, C., Lederwasch, A., Ison, N., 2011. Definition of zero emission buildings, Review and recommendations: Final report, DOI: 10.13140/RG.2.1.4470.5520

Zero net CO_2 emissions (also zero carbon, zero net carbon)	For new buildings and major renovations - *"When the amount of carbon emissions associated with a building's product and construction stages up to practical completion is zero or negative, through the use of offsets or the net export of on-site renewable energy."* For all buildings in operation - *"When the amount of carbon emissions associated with the building's operational energy on an annual basis is zero or negative. A net zero carbon building is highly energy efficient and powered from on-site and/or off-site renewable energy sources, with any remaining carbon balance offset."* The Energy Use Intensity target defined includes all of the energy consumed in the building (regulated and unregulated).	United Kingdom[134]
Carbon zero, carbon positive	**Carbon zero** buildings are defined by the Australian Sustainable Built Environment Council (ASBEC) as having no net annual emissions from direct fuel combustion (e.g. burning natural gas) and electricity use from operation of building incorporated services. **Carbon positive** moves beyond carbon zero by making additional 'positive' or 'net export' contributions by producing more energy on site than the building requires and feeding it back to the grid.	Australia[135]
Zero Energy Ready Homes	100% reduction in net operational energy use compared to the HERS Reference Home and fulfil a set of standard criteria (such as Energy Star).	United States[136]
Net zero energy	A net-zero energy home is capable of producing, at minimum, an annual output of renewable energy that is equal to the total amount of its annual consumed/purchased energy from energy utilities.	Canada[137], International
Net zero site energy	Produces at least as much energy as it uses in a year, when accounted for at the site.	National Renewable Energy Laboratory (US)[138]
Net zero source energy	Produces at least as much energy as it uses in a year, when accounted for at the source. Source energy refers to the primary energy used to generate and	National Renewable Energy Laboratory (US)

[134] Government Property Agency, 2020: Net Zero and Sustainability: Design Guide – Net Zero Annex https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/925231/Net_Zero_and_Sustainability_Annex__August_2020_.pdf
[135] https://www.yourhome.gov.au/housing/carbon-zero-carbon-positive
[136] https://www.energy.gov/eere/buildings/guidelines-participating-doe-zero-energy-ready-home-program
[137] https://www.nrcan.gc.ca/energy-efficiency/energy-efficiency-homes/buying-energy-efficient-new-home/netzero-future-building-standards/20581
[138] Torcellini, P., Pless, S., Deru, M., 2006. Zero Energy Buildings: A Critical Look at the Definition

	deliver the energy to the site.	
Net zero energy emissions	A net-zero energy emissions building produces at least as much emissions-free renewable energy as it uses from emissions-producing energy sources.	National Renewable Energy Laboratory (US)
Carbon neutral	Zero net greenhouse gas emissions	United States, Australia, International
Climate positive	Reduce amount of on-site CO2 emissions to below zero, i.e. generate more renewable energy than total net greenhouse gas emissions, recycle and export more water than used and reuse, reduce and recycle more waste than is generated.	International

Nearly zero-/Net zero-/positive-energy building definitions are focused mainly on the reduction of the operational energy demand through increasing energy efficiency and use of renewable energy carriers. These energy-centred definitions are due to the fact that energy demand is high especially in old buildings and can be reduced with energy efficiency measures. Its reduction generates benefits from the security of supply and energy expenditure perspectives. At the same time, zero-energy buildings also deliver significant reduction of the GHG emissions since primary energy use of a building accurately reflects the depletion of fossil fuels and is sufficiently proportional to CO_2 emissions.[139] Stricter energy performance requirements introduced in the building codes over the last two decades led to a decrease of the energy demand and the proportion of life cycle GHG emissions that results from operational energy is diminishing. Therefore, the reduction of the overall life cycle emission became progressively more relevant

Net zero emission/carbon neutral definitions target instead the reduction of CO_2 or GHG emissions through energy efficiency and onsite renewable energy (over-)compensation of the operational or whole lifecycle emissions of the building.

When defining a zero emission building, there are several criteria that should be taken into account, such as:

- System boundaries over the building's emissions lifecycle
- Emission reduction options
- Emission balance boundaries (net, economic, technical)

[139] B. Atanasiu, T. Boermans, A. Hermelink, S. Schimschar, J. Grozinger, M. Offermann, K. Engelund Thomsen, J. Rose, S. O. Aggerholm: Principles for nearly zero energy buildings. Paving the way for effective implementation of policy requirements. BPIE 2011.

- "Energy efficiency first" principle
- Methodological boundaries (onsite, offsite, renewables)
- Timeframe over which the building's emission impact is assessed
- Indicators and metrics
- Spatial boundaries (building, neighbourhood, city, region)

Each of these criteria will be examined in the following sections.

2.2. System boundaries over the building's emissions lifecycle.

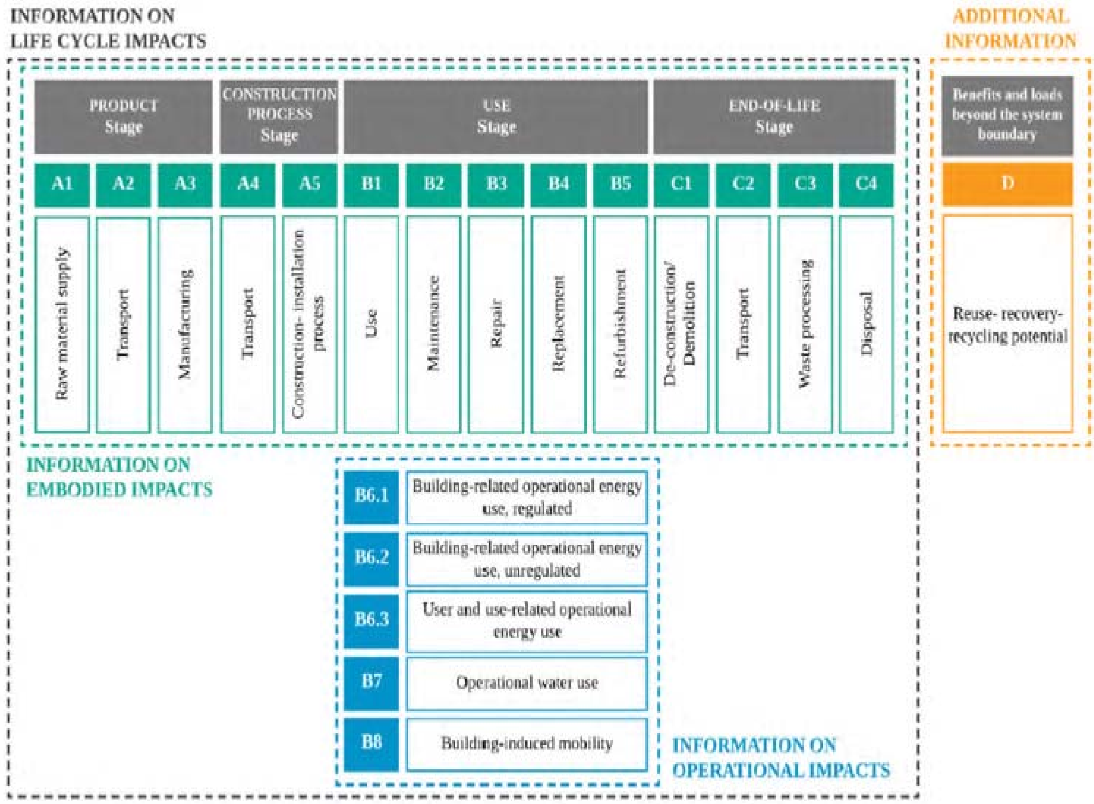
Generally, the system boundary may limit to the operational (in use) part or go beyond, over the lifecycle of the building (including the embodied emissions). So far, the focus is only on the operational phase of a building, specifically, on the regulated energy use (heating, cooling, ventilation, domestic hot water preparation, built-in lighting and auxiliary energy) as in the case of the NZEB definition. The NZEB definition leaves aside the un-regulated energy uses (such as elevators, escalators, appliances, IT equipment) which could be a significant source of greenhouse gas emissions and could be further included into the system's boundaries. The effects of some of these un-regulated energy uses (e.g. computers) are only considered with regards to their effects on the internal environment (e.g. cooling needs). The inclusion of the energy use for the provision of drinking water as well as the emissions associated with building-induced mobility was recently discussed in several studies[140].

The life cycle emissions consider additionally the greenhouse gas emissions from before and after the operation phase of a building. It includes the extraction and processing of the raw materials, manufacturing of materials and equipment, transport to the site, the construction process of the building, the installations of equipment as well as the end-of life (e.g. demolition) process and transport and disposal of waste[141]. Furthermore, the maintenance, repair and replacements is also included. Special attention should be given to the embodied emissions associated to replacement since many technical systems (including onsite renewable systems) require replacements during the lifetime of a

[140] D'Agostino, D., Mazzarella, L., 2019. What is a Nearly zero energy building? Overview, implementation and comparison of definitions. J. Build. Eng. 21, 200–212. https://doi.org/10.1016/j.jobe.2018.10.019
[141] Idem Riedy

building which could represent additional embodied emissions comparable with those of the construction phase[142].

Figure H.4: system boundaries of a building



The inclusion of the embodied emissions into the system boundaries definition provides a complete picture of the greenhouse gas emissions during the life cycle of building. However, calculating the embodied emissions is new to many projects and a complete and more accurate evaluation of the embodied emission may prove challenging, especially in the case of existing buildings for which data about the incorporated materials may not be anymore available. However, databases of average or product category data are usually available in the absence of a full Environmental Product Declaration from the manufacturer. Based on EN 15978 (CEN 2011), system boundaries are defined by a modular structure of the operational emissions which should provide transparency regarding the covered operational energy use in the emissions calculation (figure H.4)[143].

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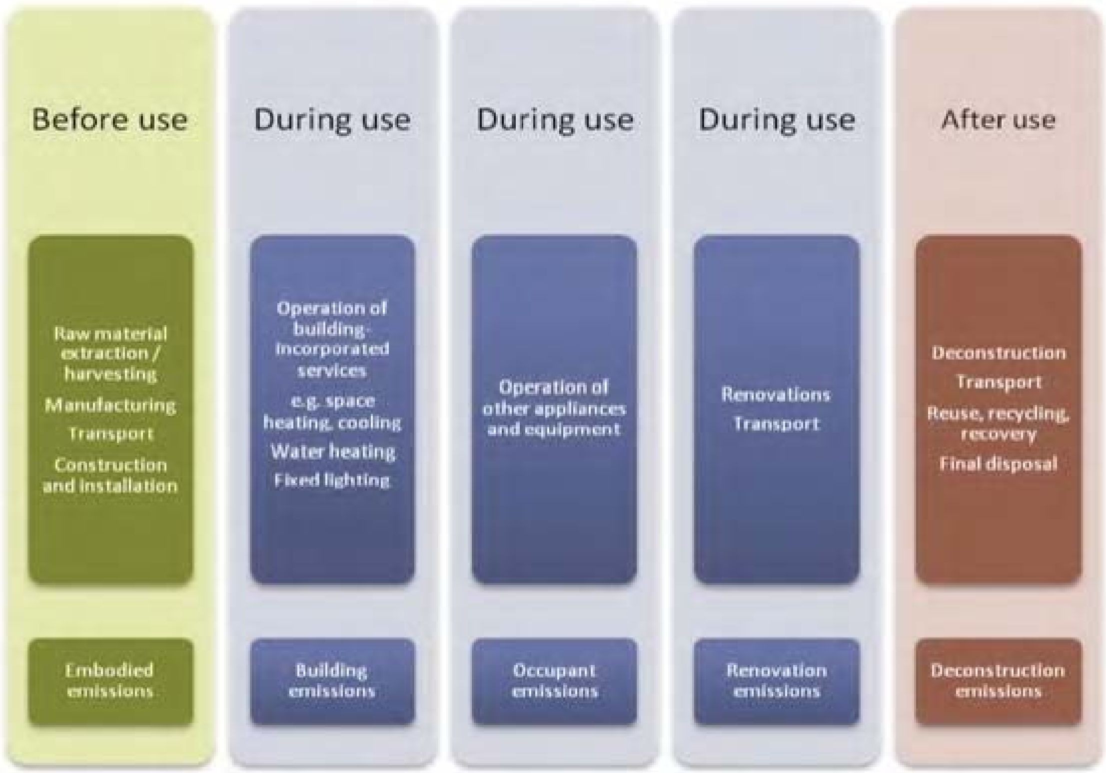
[142] Satola, D., Balouktsi, M., Lützkendorf, T., Wiberg, A.H., Gustavsen, A., 2021. How to define (net) zero greenhouse gas emissions buildings: The results of an international survey as part of IEA EBC annex 72. Build. Environ. 192, 107619. https://doi.org/10.1016/j.buildenv.2021.107619

[143] Lützkendorf, T., Frischknecht, R., 2020. (Net-) zero-emission buildings: a typology of terms and definitions. Build. Cities 1, 662–675. https://doi.org/10.5334/bc.66

According to the system boundaries definition, zero-emission buildings can be structured in several categories according to the extent they cover one or more phases of the building lifecycle (as shown in figure H.5 below):

- **Zero carbon building**, which includes the building emissions over the use/operational phase (e.g. Space heating, cooling, etc.)
- **Zero carbon occupied building,** which includes the building related emissions and the occupant emissions (e.g. appliances, other not regulated) ;
- **Zero carbon embodied, occupied building**, which includes the embodied emissions on top of the above;
- **Zero carbon life cycle**, which includes the emissions over all building phases, i.e. the above plus renovation and deconstruction emissions

Figure H.5: Conceptual breakdown of a building life cycle (adapted from the source)



2.3. Emission reduction options

The existing concepts of "zero-emission buildings" distinguish several emission reduction options, the most common ones are absolute zero-emission and net zero-emission.

Both options may either be limited to the operational emissions or cover the lifecycle of the building.

An **absolute zero-emission building** should have no emission associated to fuel or electricity to cover at all times the energy use in the operational phase or over the full lifecycle. When considering the whole life cycle emissions, the building materials should be from zero emission supply sources and the transport of the materials and the construction process should be characterised by no emission. Although absolute zero emissions during the operation phase of buildings would be technically possible with comprehensive energy efficiency measures and appropriate on-site renewable energy, it is not possible or at least it is very challenging to reach absolute zero life cycle emission buildings.

A **net zero emission** approach offers more flexibility since it implies a zero balance of the greenhouse gasses emissions over a period of operational time (typically a year) or over the lifecycle. In practice, this usually means that the building is very efficient and compensate the emissions by onsite over generation of renewable energy. Most net zero emission definitions allow for grid connection and count on it to counterbalance the emissions.

2.4. EMISSION BALANCE BOUNDARIES

In literature there are two main approaches to identify the allowable emissions reduction[144].

- To focus mainly on the reduction of the energy needs of the building through energy efficiency measures as the main step in achieving zero emissions in buildings (in line with the energy efficiency first principle[145]).
- To target mainly the emission balancing options and not necessarily giving priority to the reduction of the energy needs of a building.

Consequently there are several approaches to compensate the greenhouse gas emissions: net balance approach, economic approach and technical approach.

[144] Idem 133, 138, 142, 143, and Sartori, I., Napolitano, A., Marszal, A., Pless, S., Torcellini, P., Voss, K., 2010. Criteria for Definition of Net Zero Energy Buildings, in: Proceedings of the EuroSun 2010 Conference. Presented at the EuroSun 2010, International Solar Energy Society, Graz, Austria, pp. 1–8. https://doi.org/10.18086/eurosun.2010.06.21

[145] Directive 2012/27/EU on energy efficiency, Art 1: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02012L0027-20210101 and Energy efficiency first: accelerating towards a 2030 objective of 32.5%, September 2019, https://ec.europa.eu/info/news/energy-efficiency-first-accelerating-towards-2030-objective-2019-sep-25_en

The **net balance approach** implies that the building produces and exports the excess renewable energy to the grid although the potential benefits are attributed to the building. The approach is in line with the "energy efficiency first" principle as it is feasible for energy efficient buildings with low energy use and capacity to produce renewable energy onsite or nearby. However, the latter case is very often identified as a combination between a net balance and an economic approach since not always nearby is precisely defined.

The **economic approach** implies the offset of the operational or the whole lifecycle emissions by purchasing CO_2 emissions certificates. Although purchasing emissions allowances is a straightforward process (e.g. through a trading scheme such as ETS), only financial compensation does not lead to zero emission in buildings so this approach should be combined with other options to counterbalance the emissions.

The **technical approach** assumes technologies to extract and store the greenhouse gases from the atmosphere. Basically after the operational emissions or the whole life cycle emissions are evaluated, it should be extracted from the atmosphere an equivalent amount of emissions. Some of the available negative emissions technologies are afforestation and reforestation, land management to increase and fix carbon in soil and bioenergy production with carbon capture and storage[146]. Although the approach technically results in a reduction of greenhouse gas emissions, many aspects related to the reliability of these technologies are still under discussion, including long-term costs and liabilities as well as the risk of CO_2 leakage or release.

2.5. ENERGY EFFICIENCY ROLE

It is generally easier and cheaper to avoid energy use than to produce energy, so prioritising energy efficiency is a logical approach to zero emission buildings. The wide majority (if not all) existing zero energy and zero emission definitions stress the importance of energy efficient design and construction and prioritise energy efficiency improvements, in line with the energy efficiency first principle. The absence of energy efficiency requirements may lead to oversized renewable energy systems which would not be cost-effective and would result in wasted energy.

[146] Courvoisier, T.J., European Academies Science Advisory Council, Deutsche Akademie der Naturforscher Leopoldina (Eds.), 2018. Negative emission technologies: what role in meeting Paris Agreement targets?, EASAC policy report. EASAC Secretariat, Deutsche Akademie der Naturforscher Leopoldina, Halle (Saale).

2.6. METHODOLOGICAL BOUNDARIES

In line with the “energy efficiency first” principle, a zero emission building should be designed to minimise energy needs and improve energy efficiency. The residual operational emissions associated with the low amount of energy still required by the building could be completely offset by renewable energy produced by the building or even overcompensated if this will exceed the energy needs of the building.

Therefore, one key aspect that should be taken into consideration in the definition of a zero emission building is which type of renewable energy generation can be attributed to the building and within which system boundaries. There are several options to assess the emissions of a building by considering renewable energy generated:

- Onsite[147] i.e. renewable energy is produced on the cadaster limits of the property;
- Onsite and nearby: as above but also including nearby generation, e.g. common shared facilities built in conjunction with a larger group of buildings;
- On-site, nearby and off-site: including all renewable energy produced on-site, nearby or off-site, i.e. in the grid.

The advantage of using a calculation method based only on **on-site energy production** is that it ensures that any renewable energy taken into account in the initial calculation is strictly related to that particular building, i.e. changes in grid connections do not influence CO_2 emissions for the building. The disadvantage of this approach is that, e.g. for larger building projects, excludes a common renewable system which is not installed “onsite” from each building perspective. Another disadvantage is the risk of missing the obvious synergies that lie in sharing an installation where one building can produce energy while another uses energy. Moreover, by following only the onsite approach, it will be more challenging to reach a zero emission level from a building owner’s perspective (micro perspective). A possible approach to overcome the above challenges could be to focus on the **ownership** of the renewable energy installation, rather than on its location. However, in any case, the approach should be designed carefully, with a view to avoiding the risk of double counting (i.e. counting avoided emissions both in the balance sheet of the building and in the balance sheet of the purchaser of exported energy).

The advantage of including **nearby renewable energy production** is that a larger group of buildings or district could benefit from a common centralised RES production (e.g. district heat or cold) and this could also help even out some peak demands in the system.

[147] Including biomass transported to and used on-site.

However, in order to avoid any changes in emissions, it will be necessary to define specific boundaries as to how the use of nearby renewable production can be expanded to other future new buildings which may be constructed in the same neighboring in order to not undermine the emission levels of the initial group of buildings.

The further inclusion into the definition of the **offsite renewable energy distributed through the grid** it allows the possibility to purchase renewable energy supplied to the building via a district heating network, generated with geothermal, solar (PV or thermal) and biomass or from the electricity grid. This might become increasingly relevant with the blending of biogas and, in future, of hydrogen in the natural gas grid, thus leading to lower emission factors for natural gas. This option has the advantage of an open and flexible zero emission concept accessible to all buildings despite the local spatial limitations. At the same time, it will be necessary to set-up a solid system to account the renewable energy to be attributed to each building and avoid fraud or double counting of renewable energy coming from the grid.

2.7. TIMEFRAME FOR THE ASSESSMENT OF THE BUILDING'S EMISSION IMPACT

To evaluate the operational energy balance of a building and then the associated emissions, two type of calculation methods are commonly used: **steady-state (static) methods and dynamic methods.** In the steady state methods the calculation is performed in a stationary regime overlooking the real dynamic behaviour of the building. The heating and cooling season have relatively fixed lengths. On the other hand, the dynamic methods take into account the actual dynamic behaviour of the environment, the variability of heat gains, the ventilation and infiltration rate as well as the thermal-mass of the building. Dynamic methods produce results that are closer to the real behaviour of the analysed building and are also best suited to take into account changing climate. However, the dynamic approach requires more input data and is generally more costly.

As regards timeframes, the existing definitions uses annual timeframes, although theoretically also monthly/seasonal timeframes could have advantages but their implementation is highly complex.

2.8. INDICATORS AND METRICS

The operational part of a life cycle assessment is based on the calculation of the final energy demand of the building, generally including heating, cooling, hot water supply, ventilation or air conditioning, auxiliary energy for pumps, and fixed lighting, sometimes also covering occupants' use of plug-in appliances (so-called plug loads). Using primary energy factors (PEF), it is possible to determine the primary non-renewable energy demand. By using emission factors, the final energy demand of a building can be converted into GHG emissions[148]. Energy demand is often considered as a proxy for carbon emissions and several building assessment frameworks use energy demand to measure the performance of buildings with respect to climate change. However the relation between energy demand and carbon emissions is not so straightforward in an energy system which is becoming more and more decarbonised.

Moving from PEF to carbon emissions coefficients, there is a strong link between these coefficients and PEFs for non-renewable energy sources such as fossil fuels. However, this link becomes weaker for energy sources that are less clearly defined as non-renewable.

2.8.1. Spatial boundaries (building, neighbourhood, city, region)

A mandatory first step in having a clear picture of a zero emission building is to define the space boundaries which may limit to a single construction or go beyond to a group, a neighbourhood, a city or even the whole national building stock.

In most of the cases, the zero emission definition focuses on a single building. Several large scale zero energy projects address also the greenhouse gases emission (GHG) reduction. Although it is clear that having broader spatial boundaries implies more substantial impact in the emissions reduction, a more complex methodology is needed.

3. Differences between nearly zero-energy building (NZEB) and zero-emission building (ZEB) definition

Article 2 of the EPBD defines “nearly zero-energy building” as “a building that has a very high energy performance” and “the nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby”.

Annex 1 of EPBD indicates that “the energy performance of a building shall be “be expressed by a numeric indicator of primary energy use in kWh/m^2.year” and “shall be determined on the basis of calculated or actual energy use and shall reflect typical energy use for space heating, space cooling, domestic hot water, ventilation, built-in lighting and other technical building systems”.

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[148] The ISO 16745-1:2017 standard on Sustainability in buildings and civil engineering works – Carbon metric of an existing building during use stage provides a set of methods for the calculation, reporting, communication and verification of a collection of carbon metrics for GHG emissions arising from the measured energy use during the activity of an existing building, the measured user-related energy use, and other relevant GHG emissions and removals. The carbon metric used is the sum of annual greenhouse gas emissions and removals, expressed as CO2 equivalents, associated to the use phase of a building.

In the table below it is presented an overview of the potential differences between the NZEB definition and possible zero emission building definitions.

Table H.3: Comparison between NZEB and ZEB

Criteria	Nearly zero-energy building	Zero-emission building
Metrics	A numeric indicator of primary energy use in kWh/m^2.year	Numeric indicators of greenhouse gas emission produced in $kgCO2_{eq}/(m^2.y)$
System boundaries	Regulated energy i.e. for heating, space cooling, domestic hot water, ventilation, built-in lighting and other technical building systems. Although not compulsory, in several Member States the emissions associated to the energy scope is calculated and indicated on the energy performance certificates.	Typically emissions from all energy consumption of the building i.e. regulated and non-regulated energy consumption. In its extended scope, it covers embodied emissions in materials and equipment, emissions from energy consumed in the construction, renovation & maintenance and end-of-life phase and it may covers emissions from other energy uses in operational phase, e.g. for the provision of drinking water, for mobility and e-mobility.
Energy efficiency first principle	Clearly follows the energy efficiency first principle ("a very high energy performance", "nearly zero or very low amount of energy")	This is the overarching principle. There is a wide agreement that measures to reduce the energy needs of the building are of a high importance in order to reach zero emission buildings. Generally it is easier and more cost-effective to ensure low energy needs than to produce additional clean energy.
Renewable energy	Clearly stipulates that "energy required should be covered to a very significant extent by energy from renewable sources"	Renewable energy is necessary to supply the energy needs of the building and potentially to also offset partially or entirely other direct or embodied emissions.
Balance boundaries	Renewable energy produced "onsite" or "nearby", although the overall balance is in primary energy	Exclusively renewable energy to supply the energy needs of the building and potentially to also offset partially or entirely other direct or embodied emissions. It may be any combination between onsite, nearby and offsite, but the latter should be accompanied by a clear framework to avoid double counting.
Timeframe for counting energy/emissions	On annual basis	Usually on annual basis (at least for operational emissions)
Spatial boundaries	At building level	At building level

NZEBs represent today the current construction requirements for new buildings, and in some Member States also for existing building undergoing major renovations too. As mentioned before, the development of NZEB definitions has been often carried out within the calculations of cost-optimal levels, according to Article 5 of the EPBD. While more time is needed to fully assess the NZEB uptake in the EU following their official entry into force (2021 for all new buildings and 2019 for all new buildings), evidence shows that NZEBs are becoming cost-optimal (noting that it is difficult to reflect the evolution of cost-optimal level as the third round for the cost-optimal calculations from Member States are foreseen for March 2023), as new technologies are proven and their market upscale is expected to reduce their costs. The type of technologies deployed will be similar for both NZEBs and ZEBs (e.g. renewable sources solutions, high-efficiency appliances and improved insulation and glazing of building envelope)However, a notable difference between the two concepts is the fact that applying a whole life cycle emission calculation means choosing technologies and materials based on their embodied emissions alongside other criteria.

Some studies indicate that there is no significant difference between zero energy building costs and modeled conventional building costs, noting that the magnitude of cost difference is affected by the size of the building, type of the building and location of the building[149]. From a life-cycle perspective, and taking into considerations that ZEBs could reduce energy needs, emissions and costs compared to conventional buildings, the total cost needed for a ZEB may be comparable[150].

3.1. Towards a ZEB definition in the EPBD

A zero emission buildings definition should fulfil several general principles such as:

- To be feasible and simple to transpose and implement;
- To be ambitious, avoid lock-in effects, be aligned with the 2030 climate and energy targets and to the long-term decarbonisation goals enshrined in the Climate Law;
- To build on synergies with other existing legislation or planned initiatives contributing to the decarbonisation of the buildings stock;

[149] Does zero energy building cost more? – An empirical comparison of the construction costs for zero energy education building in United States, 2019 https://www.sciencedirect.com/science/article/pii/S221067071831237X

[150] UK Green Buildings Council: Building the Case for Net Zero: A feasibility study into the design, delivery and cost of new net zero carbon buildings, September 2020

- To ensure comparable implementation across the European Union and be sufficiently flexible and acknowledge the subsidiarity principle leaving the Member States to shape it in the most suitable way according to their context.

Taking into account the technical challenges and options presented in the previous chapters, the zero emission building definition for the EPBD can be based on the following general criteria:

- ***System boundaries over the building's emissions lifecycle.*** The operational emissions of buildings are clearly within the EPBD scope and should be fully addressed. Non-regulated energy of the building could be also considered, particularly regarding its effects on the building performance. On embodied emissions, the definition should be associated to other legislative acts and initiatives which address embodied emissions over the building lifecycle.

- ***Emission reduction options.*** The definition could be based on a net emission balance. This is the option that can best guarantee the necessary decrease of emissions in order to achieve the EU's decarbonisation goals.

- ***Energy efficiency first principle.*** A zero emission building definition should be in line with the "energy efficiency first principle" since it is generally agreed that reducing first the energy needs of the building is a more sustainable and cost-effective way to reduce emissions than investing in additional clean energy generation to compensate the low energy performance of the building. However, the definition should provide a sufficiently flexible balance between energy efficiency and renewable energy supply. This is particularly relevant for existing buildings that, due to their characteristics and local context, may present a higher reliance on RES to compensate for their lower performance.

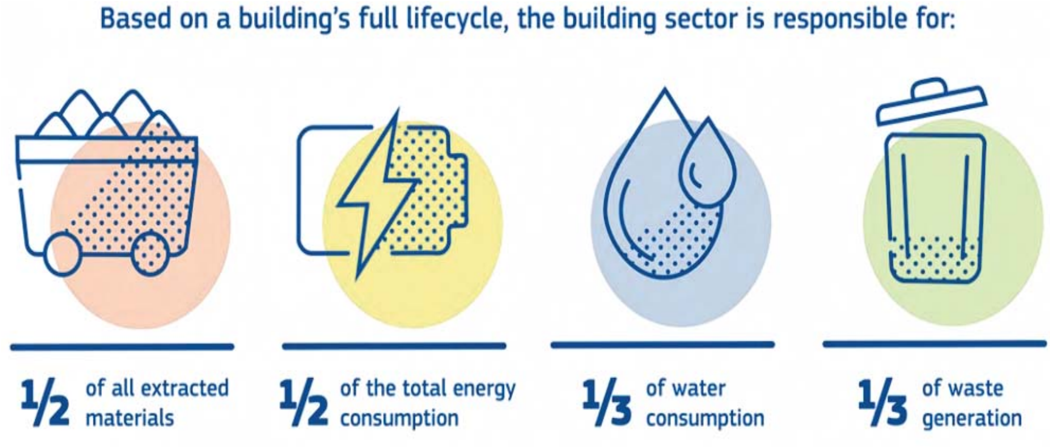
- ***Methodological boundaries.*** The definition could emphasise onsite renewable energy production. Renewable energy from energy communities or district heating could also be considered. Under certain conditionality related to specific technical constraint of the buildings or due to their location, it could allow renewable energy coming from the grid to supply the remaining need of the buildings. The rules to calculate emission factors for the electricity coming from the grid should reflect properly the exchange between on-site and on-grid to the grid.

- ***Indicators and metrics*** The definition should be primarily based on the operational use of the building and include requirements and cross-references to other related legislation to report whole life-cycle carbon emissions. As concerns the metric, the definition could use both an energy performance indicator (e.g. $kWh/m^2.y$) and a carbon metric such as $kgCO2eq/(m^2.y)$.

- ***Space boundaries.*** The definition should be at level of building.

4. WHOLE-LIFE CYCLE EMISSIONS OF BUILDINGS AND OTHER ENVIRONMENTAL & SUSTAINABILITY ASPECTS

Figure H.6: Environmental impacts of the building sector[151]



4.1. THE CURRENT STATE OF PLAY

With new buildings being constructed and existing buildings renovated, embodied carbon is emitted during extraction and manufacturing of construction materials, transport and construction. The embodied carbon in construction is estimated to account for about 10% of total yearly greenhouse gas emissions worldwide[152].

The relative importance of embodied emissions compared with operational emissions will gradually increase over time, as buildings are constructed and renovated to high levels of energy performances, this reducing direct emissions. On the building level, the share of embodied carbon as a part of the whole life carbon (including the full life cycle) varies greatly: while the average share of embodied emissions from buildings is approximately 20–25% of life cycle GHG emissions, this figure is higher for highly energy-efficient buildings[153].

It should also be noted that the legislative development for more stringent operational performance requirements may increase embodied carbon emissions from buildings in absolute but also relative terms. This is explained by the fact that in some cases, high-performance buildings require more materials and services[154]. It is, however, possible to

[151] Level(s) https://ec.europa.eu/environment/levels_en#ecl-inpage-261
[152] IRP, Resource Efficiency and Climate Change: Material Efficiency Strategies for a Low-Carbon Future, 2020. UN Environment Emissions Gap Report 2019.
[153] Röck, M. et al. (2020) "Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation".
[154] *Ibid.*

build high-energy performance buildings with low embodied emissions. An analysis of more than 650 global lifecycle assessment (LCA)[155] case studies demonstrated the possibility to design buildings with low lifecycle emissions regardless of the building regulations they have to comply with[156].

Improving energy efficiency will deliver significant carbon emissions reduction but not necessarily up to zero emissions. Measures addressing embodied emissions will pave the way for new buildings maximising the efficient and smart use of materials which will facilitate the decarbonisation of other sectors. 68% of the respondents to the public consultation want the EPBD to include measures to report on whole life-cycle carbon emissions from buildings.

4.2. Overview of existing policies in Member States across Europe

European regulations for energy performance in new buildings have been transposed across the continent leading to low energy demands in the operational phase. Some Member States are thus starting to consider embodied carbon in their national building regulations.

In its publication of May 2021 'Whole-life Carbon: Challenges and solutions for highly efficient and climate-neutral buildings'[157], Buildings Performance Institute Europe (BPIE) has identified countries that have implemented such advanced regulations. According to BPIE, three countries have introduced CO2 limits for a large share of new buildings, while two other countries have plans to do so. Three additional countries have Life Cycle Analysis (LCA) requirements for public buildings.

The national policies are detailed in the BPIE report as follow:

- Denmark's new regulation sets whole-life carbon emissions for new buildings, encompassing both operational and embodied emissions, based on LCA. Plans for the progressive tightening of CO2 limits.
- The Netherlands has since 2017 required all new residential and office buildings whose surface exceeds 100m2 to account for and report their embodied impacts based on a simplified LCA using a national method. All impacts are converted into a monetary value, which since 2018 is used to set a "mandatory environmental impact cap" for new buildings.
- Finland and Sweden have developed simplified LCA methodologies and whole-life carbon databases, intending to facilitate whole-life carbon

[155] LCA applied to buildings aims to assess the potential environmental of buildings over the complete life cycle, from materials production to the end-of-life and management of waste disposal.
[156] Röck, M. et al. (2020)
[157] https://www.bpie.eu/wp-content/uploads/2021/05/BPIE_WLC_Summary-report_final.pdf

accounting and regulation in the future. Finland plans to introduce CO2 limits for new buildings by 2025 and Sweden by 2027.

- France's pending new building regulation (RE2020 foreseen for July 2021) aims to reduce the climate impact of new buildings by integrating enforced energy efficiency requirements and whole-life carbon considerations. Base on European standards, the LCA methodology has been further developed together with the industry and features both energy and whole-life carbon emissions.
- Germany, Switzerland and the UK have all introduced LCA requirements for public buildings/projects.

4.3. INTERLINKAGES WITH OTHER POLICIES.

The reduction of lifecycle emissions of buildings remains largely unregulated at European level. A number of policies have started to tackle some aspects necessary to address embodied carbon, however an overall strategy has yet to be defined with a view to achieving the Union's decarbonisation objectives. The EPBD by setting a vision for the building stock for 2050 can help to draw up a timetable giving Member States and the construction industry visibility on the measures planned over the next years.

Figure H.78: Scope of various EU regulatory and non-regulatory measures against the building lifecycle[158]

[158] The references in the table are as follow: [6] the basic requirements for construction works set out in the Construction Products Regulation (CPR) include sustainable use of natural resources; however, the regulation does not impose minimum performance requirements for the whole product lifecycle, including embodied carbon. The ongoing revision could possibly introduce recycled content requirements for certain construction products (Circular Economy Action Plan). - [7] Waste Framework Directive – [8] The emissions trading scheme (ETS) covers the power sector and energy-intensive industries, such as concrete, which means that buildings are indirectly affected. The Commission's forthcoming June package of energy and climate laws may include a proposal to extend the ETS to sectors such as building and road transport. - [9] Level(s) embraces a full lifecycle approach and the methodology to calculate the GHG emissions of the building follows the relevant global and EU standards for sustainable construction (ISO 14040/44, EN 15804 and EN 15978). – [10] The current EU Taxonomy only recognises improvements to the energy and carbon performance of buildings during the use phase (climate change mitigation and adaptation efforts). In going forward, the eligibility criteria will also include the "do no significant harm" requirement in relation to four other environmental objectives – water, circular economy, pollution prevention and biodiversity – for which full taxonomy systems are yet to be developed.

Table 1: Scope of various EU regulatory and non-regulatory measures against the building lifecycle.

Lifecycle stages	Modules	EU policy instruments							
		EPBD	EED	CPR[6]	Ecodesign	WFD[7]	ETS[8]	Level(s)[9]	Taxonomy[10]
PRODUCTION	A1 Raw material supply	-	-	(*)	•	-	•	••	(*)
	A2 Transport	-	-	-	-	-	(*)	••	(*)
	A3 Manufacturing	-	-	(*)	-	-	•	••	(*)
CONSTRUCTION	A4 Transport	-	-	-	-	-	(*)	••	(*)
	A5 Construction installation process	-	-	(*)	-	-	-	••	(*)
USE	B2 Maintenance	-	-	(*)	-	-	-	••	(*)
	B3 Repair	-	-	(*)	-	-	-	••	(*)
	B4 Replacement	-	-	(*)	-	-	-	••	(*)
	B5 Refurbishment	-	-	(*)	-	-	-	••	(*)
	B6 Operational energy use	••	••	-	•	-	(*)	••	••
END-OF-LIFE	C1 Deconstruction	-	-	(*)	-	•	-	••	(*)
	C2 Transport	-	-	-	-	-	(*)	••	(*)
	C3 Waste processing	-	-	-	-	••	-	••	(*)
	C4 Disposal	-	-	-	•	••	-	••	(*)
BEYOND LIFE	D Reuse/recycle	-	-	(*)	•	•	-	••	(*)

Partially covered · Fully covered · Under revision

Figure[159] H.7 presents the main EU policy instruments, existing and proposed, and the corresponding lifecycle stages of buildings they address. The modules are based on the commonly used European standard (EN 15978) for the assessment of the environmental performance of buildings.

The EU Sustainable Finance Taxonomy sets “Do No Significant Harm” (DNSH) requirements for different activities, including for buildings. In its delegated act[160], technical screening criteria for new constructions have been defined: for buildings larger than 5000 m2, the life-cycle Global Warming Potential (GWP)[161] of the building

[159] BPIE (2021); ‘Whole-life Carbon: Challenges and solutions for highly efficient and climate-neutral buildings’.

[160] COMMISSION DELEGATED REGULATION (EU) …/... supplementing Regulation (EU) 2020/852 of the European Parliament and of the Council by establishing the technical screening criteria for determining the conditions under which an economic activity qualifies as contributing substantially to climate change mitigation or climate change adaptation and for determining whether that economic activity causes no significant harm to any of the other environmental objectives C/2021/2800 final.

[161] The GWP is communicated as a numeric indicator for each life cycle stage expressed as kgCO2e/m2 (of useful internal floor area) averaged for one year of a reference study period of 50 years. The data selection, scenario definition and calculations are carried out in accordance with EN 15978 (BS EN 15978:2011. Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method). The scope of building elements and technical equipment is as defined in the Level(s) common EU

resulting from the construction has been calculated for each stage in the life cycle and is disclosed to investors and clients on demand.

In the current revision of the EED, Member States could be encouraged to require contracting authorities to take account of wider sustainability in public procurement practices, in particular whole life-cycle of carbon emissions of buildings.

Under the Renovation Wave, an initiative to set up a 2050 whole life-cycle performance roadmap to reduce carbon emissions from buildings and advancing national benchmarking with Member States is under preparation.

For all these initiatives, the introduction of indicators and measures on embodied carbon will be based on the European framework for sustainable buildings, Level(s)[162], which is designed to assess and report on sustainability aspects throughout the lifetime of buildings

4.4. Description of options for the introduction of whole-life cycle emissions of buildings and other environmental & sustainability aspects

Unlike building's operational energy use, which is more visible and easier to measure, "embodied" environmental impacts are hidden and often overlooked. The introduction of a definition of "zero emission buildings", enriched with further criteria on embodied carbon and other sustainability indicators (ZEB3) would be an important step toward reducing the significant environmental impacts associated with construction materials and raising awareness on whole-life cycle emissions of buildings in Europe and beyond.

Considering the lifecycle of buildings, new buildings should not need to undergo major renovation by 2050 and they will not constitute most of the overall building stock by mid-century. However, requisites for new buildings are likely to become a benchmark for renovation as well and to foster the decarbonisation of the overall existing stock.

Requirement to disclose whole life-cycle carbon

The introduction of reporting on embodied carbon linked to "zero emission buildings" represents a significant opportunity to begin integrating "whole-life carbon" in the EPBD, and more broadly in the European regulatory framework. ZEB3 should enable

framework for indicator 1.2. Where a national calculation tool exists, or is required for making disclosures or for obtaining building permits, the respective tool may be used to provide the required disclosure. Other calculation tools may be used if they fulfil the minimum criteria laid down by the Level(s) common EU framework (https://susproc.jrc.ec.europa.eu/product-bureau/product-groups/412/documents), see indicator 1.2 user manual.

[162] https://ec.europa.eu/environment/levels_en

consistent, predictable, efficient and transparent accounting of operational and whole life carbon within a clear timeline.

For embodied carbon, this timeline could start from a voluntary to a mandatory disclosure of information for certain categories of buildings (new buildings above a certain size, all new buildings.), with all buildings covered by 2030. Large new buildings could lead the way, first in the disclosure of information and then in the consideration of limit values, which will be set gradually from 2030 and onward. These limit values will be developed based on a range of studies and a first set of such limit values could be presented in a next EPBD revision.

Voluntary disclosure of information on embodied carbon could also be included in other instruments, such as Energy Performance Certificates. It shall also be considered that long-term renovation strategies encompass an overview of whole life carbon for new buildings and substantially renovated buildings.

Methodology and indicators to be used

The calculation of embodied carbon in buildings present several technical and analytical challenges, also due to the availability of source data. There is currently no uniform methodology, although various efforts are in place. The most appropriate approach seems to be that based on LCA (Life-Cycle-Assessment), the well-established methodology to assess environmental impacts and resource consumption at each stage of the building's lifecycle, from material extraction to construction and use, to the demolishing of the building.

In this regard, the European Level(s) framework shall be used for the calculation of the life-cycle Global Warming Potential (GWP). This framework is also referenced in the EU Sustainable Finance Taxonomy. Some flexibility should be left to Member States to use equivalent methodologies. EN standards EN 15978 and EN 15804 also provide a methodology framework. EN 15804 is developed for whole life cycle environmental impact of construction works and is adopted in most parts of the EU, by the industry and by governments.

Based on comments received from the open public consultation, the vision for new buildings should include life-cycle emissions and refer to a timeline. It should also include a minimal renewable energy shares. Any reporting obligations introduced in the EPBD should be based on a harmonised EU methodology. [163]

[163] Some initiatives (e.g., Level(s)) and standards (EN 15978 and EN 15804) are already working in this direction. EN 15804 is developed for whole life cycle environmental impact of construction works and is adopted in most parts of the EU, by the industry and by governments.

Annex I: E-mobility

1. Introduction

The European Green Deal has set the key objective to deliver a 90% reduction in transport-related greenhouse gas emissions by 2050 to support the EU's aim to become the first climate-neutral continent. The provisions on e-mobility in the EPBD supports the CTP, the Renovation Wave Strategy, the Smart and Sustainable Mobility Strategy and the Energy System Integration Strategy.

The deployment of private charging is as important for the growth of electromobility[164] and the decarbonisation of transport as that of charging accessible to the public. The Commission's Communication on a Sustainable and Smart Mobility Strategy confirms this and include the ambition to have at least 30 million zero-emission vehicles on the road by 2030 and that by 2050 nearly all cars, vans, buses as well as new heavy-duty vehicles will be zero-emission

The electrification of transport is of pivotal importance for decarbonising the transport sector and raising the share of renewable energy in the energy system. The impact of electric vehicles will be important in this regard. Since the previous EPBD review in 2016, the electric vehicles market has strongly matured. Electric cars have seen a rapid increase in terms of total vehicle registrations and in 2020, sales of electric cars accounted for 10.5% of all new vehicle registrations, compared to 3% in the year before (www.acea.be).

In 2050 all passenger cars should be zero emission. In the Fit for 55-scenario, the expectation for the number of EVs in the EU in 2030 is 35 million and in 2050 more than 200 million (compared to 1 million EVs in 2020)[165]. For electric 2wheelers (e-scooters and e-motorcycles) the expectation is 1,6 million vehicles in 2030 and 42 million vehicles in 2050.[166]

A rapid increase is also expected for e-bikes, where the growth rate between 2019 and 2017 was 64%. The sales in EU in 2019 amounted to 3,4 million e-bikes in 2019[167]. A

[164] Including the entire range of road vehicles from those with electric assist to human power (like electric bicycles, tricycles, and similar, including cargo-bikes) to fully electrically propelled road-vehicles (typically electric cars or vans).
[165] Fit for 55 MIX scenario, electric private cars.
[166] Fit for 55 MIX scenario, electric 2wheelers.
[167] European EPAC Sales (EU28).

forecast for 2030 is 17 million e-bikes.[168] An interesting sub-category is e-cargo bikes which currently represent 4% of the total electric bicycle sales in Germany.[169]

1.1 Publicly accessible versus private recharging infrastructure

The total number of recharging points in private buildings in the EU is not known since there are no reporting obligations. The National Plans submitted under the AFID mainly contains information on publicly accessible recharging points.

The total number of publicly accessible recharging points in the EU was approximately 165 000 in 2019[170], representing a growth of almost 40% between 2018 and 2019. The growth was concentrated in very few member States and approx. 70% of all publicly available recharging infrastructure is today located in Germany, France and the Netherlands.

In terms of number of registered electric vehicles per publicly accessible recharging point, in 2020, Member States had ratios between the number of registered electric vehicles per recharging point ranging from 3.6 and 20.7. [171] Lack of infrastructure is a major barrier to the uptake of EVs, and the 2030 and 2050 targets will not be reached unless an appropriate recharging infrastructure is in place.

For publicly accessible recharging infrastructure, the AFIR IA concluded that it could be considered sufficient if for each battery electric vehicle a total of 1 kW recharging power was installed and for each plug in hybrid a total of 0.66 kW recharging power was installed. Assuming an average power output of 11 kW per recharging point, this would correspond to an infrastructure – electric vehicle ratio of 1-12.

In the AFIR IA it was also assumed that around 40% of all recharging events for battery electric vehicles will take place at publicly accessible recharging points towards 2030, leaving an important part of all recharging events within the scope of the EPBD (or in smaller private buildings not covered by the EPBD nor by AFIR). However, the need for recharging infrastructure in private buildings could be higher as it is likely that a majority of users consider recharging overnight at home as a desired and convenient way of recharging. There is also a need for publicly accessible over-night recharging in cities for residents without a private parking place in or near their home.

For recharging in private buildings the number of recharging points depend to a high degree on the usage pattern of the EV owner. Some EV owners own or rent their own

[168] European Cyclists Federation, www.ecf.com
[169] https://www.ziv-zweirad.de/fileadmin/redakteure/Downloads/Marktdaten/PM_2021_10.03._ZIV-Praesentation_10.03.2021_mit_Text.pdf
[170] SWD(2021) 631 final AFIR Impact Assessment
[171] SWD(2021) 631 final AFIR Impact Assessment

parking space where the car is usually parked overnight and they would need a recharging point at this parking place. In this use case one recharging point per parking space/EV would be needed. Another case is an EV owner who parks overnight on the street, in different parking places depending on availability. For this case the EV owner depends on publicly accessible recharging in the street which could be combined with private recharging in the workplace if the EV is used for commuting[172]. The necessary shift to more sustainable modes of transport is also a reason to facilitate charging for e-bikes and e-scooters.

All this implies that estimating the number of recharging points needed in private buildings will depend to a high degree on how the usage patterns evolve, and it will be very different from country to country and also different between dense city centres, suburbs, small cities or rural areas. Even if the number of private recharging points needed is difficult to estimate, it is clear that access for consumers to recharging points at home or at work is crucial for encouraging the move away from ICEs.

Stakeholders, for instance cities, have signalled that they are increasingly looking for ways to get infrastructure off their streets and into the private domain, for reasons of visual pollution, occupancy of public space and the nuisance caused by road works necessary to deploy public infrastructure.

On the other hand, many citizens in city centres rely on parking on street for overnight parking, so there is a need also for publicly accessible recharging infrastructure in city centres. Some cities are mitigating the need for roadworks by making best use of existing infrastructure when deploying recharging points, e.g. by integrating them in existing electrified structures such as lamp posts (in this way, the existing ducting can be exploited and cable replacement can be accompanied by the replacement of inefficient lighting with LEDs) or on-road telecom distribution boxes, or coupling them to existing electrified networks, such as rail, metro or tram lines.

Anyhow sufficient private infrastructure in cities will be key for the uptake of e-mobility in urban areas. Installation of recharging points in private parking spaces, typically inside or flanked to buildings, is essential to support the market of electric vehicles, complementing the AFIR. In multi-apartment blocks and non-residential buildings, the freedom to install recharging points may be limited by the necessity to get an agreement from the other co-owners to intervene on the building infrastructure or to cross private spaces. Measures to facilitate this have been adopted in some Member States, such as France and Spain but barriers still exist in the majority of MS, with the assembly

[172] However, and as raised in the public consultation, with a shift to sustainable mobility, where EVs are one part of the solution, the aim is not to replicate use patterns from ICE vehicles, but instead take the opportunity of shifting to more sustainable modes of transport (walking, cycling, e-scooters, public transport etc) and also promote car sharing.

blocking requests by single owners even with disputable objections (e.g. visual pollution of ducts or of the charging station itself). Furthermore, the construction and the major renovation of buildings are special opportunities to install recharging points, or at least facilitate their later installation.

The availability of safe and easily accessible bike parking is an important incentive to drive behavioral change towards more sustainable transport modes in line with the Climate Target Plan. Bicycle sales are increasing in the EU with about 22 million units sold in 2020, up from about 20 million units in 2019. During the pandemic there was a raise in biking and the Resilience and Recovery Facility include support for sustainable mobility including cycling infrastructure which is likely to promote further growth.

Promoting green mobility is a key part of the European Green Deal and buildings can play an important role in providing the necessary infrastructure, not only for recharging of electric vehicles but also for bikes including ebikes and cargobikes.

For the vast majority of electric bikes, batteries can be removed from the bike and charged in the apartment or in an office space through a standard household power socket. However an important barrier to cycling is lack of safe bike parkings. The Commission recommendation on Energy Efficiency First principle suggests obligations to provide bike parking and e-bike charging points through buildings codes[173].

The Commission recommendation on building modernization[174] states that Member States without requirements or guidelines on bicycle parking should develop as a minimum, guidelines to local authorities on the inclusion of bicycle parking requirements in building regulations and urban planning policies. These guidelines should include both quantitative (i.e. number of parking spaces) as well as qualitative elements.

2. Interlinkages with other policies

In the “Fit for 55” package, electro-mobility is supported through a number of legislative measures across different proposals:

- CO_2 and cars[175]

  The CO_2 emission performance standards provide a strong push for deployment of zero- and low-emission vehicles.

[173] C(2021) 7014 final, Annex
[174] COMMISSION RECOMMENDATION (EU) 2019/1019
[175] COM (2021) 556. Proposal for a regulation of the European Parliament and of the Council amending Regulation (EU) 2019/631 as regards strengthening the CO2 emission performance standards for new passenger cars and new light commercial vehicles in line with the Union’s increased climate ambition.

- AFIR proposal[176]

AFIR contain provisions for Member States to ensure minimum coverage of publicly accessible recharging points dedicated to light- and heavy-duty road transport vehicles on their territory, including on the TEN-T core and comprehensive network.

It also 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.

- Electricity Regulation and Electricity Directive[177]

- Energy Efficiency Directive Art.7[178]

- The revision of the Renewable Energy Directive[179]

  The proposal include provisions to facilitate system integration of renewable electricity by the following means:

    - TSO and DSOs are required to make available information on the share of RES and the GHG content of the electricity they supply, in order to increase transparency and give more information to electricity market players, aggregators, consumers and end-users
    - Battery manufacturers must enable access to information on battery capacity, state of health, state of charge and power set point, to battery owners as well as third parties acting on their behalf;
    - Member States shall ensure smart charging capability for non-publicly accessible normal power recharging points, due to their relevance to energy system integration;
    - Member States shall ensure that regulatory provisions concerning the use of storage and balancing assets do not discriminate against participation of small and/or mobile storage systems in the flexibility, balancing and storage services market.

[176] COM(2021) 559 Final.
[177] Recast electricity Regulation 2019/943 and the recast electricity Directive 2019/944 (not part of the ‘Fit for 55’ package).
[178] Directive 2012/27/EU.
[179] COM(2021) 557 Final.

- ETS extension to road transport[180]

3. Current provisions on e-mobility in the EPBD

The current EPBD includes the following provisions on e-mobility:

- Article 8(2) mandates the installation of recharging points (one in every ten parking spaces) and ducting infrastructure (one in every five parking spaces) in the car parks of non-residential buildings with more than 10 parking spaces. This provision applies to all new non-residential buildings and major renovations.
- Article 8(3) requires Member States to 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.
- Article 8(5) mandates ducting infrastructure for all parking spaces in new built and major renovation of residential buildings with more than ten parking spaces.

Summary of electromobility requirements

Scope		MS obligation
New buildings and buildings undergoing major renovation	Non-residential buildings with more than 10 parking spaces	Ensure the installation of at least 1 recharging point Ensure the installation of ducting infrastructure for at least 1 in 5 parking spaces
	Residential buildings with more than 10 parking spaces	Ensure the installation of ducting infrastructure for every parking space
Existing buildings	Non-residential buildings with more than 20 parking spaces	Set out requirements for the installation of a minimum number of recharging points — applicable from 2025

The objective of the provisions is to ensure that a share of the total planned or already available parking spaces is not limited to petrol or diesel cars but also compatible with electric vehicles. The provisions are therefore compatible with urban sustainable transport policies aiming to reduce the total number of parking spaces or to regulate the role of individual vehicles in densely populated urban areas.

4. Current implementation in the Member States.

The provisions on e-mobility in the EPBD were introduced in the 2016 review and the deadline for transposition was 10 March 2020. In the first progress report made in January 2021, only 3 MSs had fully implemented the e-mobility provisions of the EPBD (Art 8.2-8.8). However, at the CA EPBD meeting in November 2020, 13 MSs reported that they had made substantial progress on implementation.

[180] COM 2021 (551).

Further conclusions from the CA EPBD meeting were that most Member States will stick to the EPBD minimum requirements. A few, however, have set their own requirements, based on analysis of the local electro-mobility market. A majority of MSs is of the view that the minimum implementation of recharging points will not be enough in the future. It is the hope that based on local demand more than the minimum number of recharging points will be installed. Several MS have taken additional initiatives to support e-mobility such as:

- tax exemption/reduction for EVs
- procurement support
- free parking in public areas, free municipal charging stations, free access to limited traffic areas, use of shuttle lanes
- charging points integrated with PV and metering system
- roll out of highway recharging points
- support to residential owners for installation of recharging points
- public co-funding of private and publicly accessible recharging points

The following additional type of elements were discussed:

- specifications for ducting infrastructure
- specifications relating to fire safety
- specifications for recharging points including relating to accessibility for persons with disabilities
- requirements related to dedicated parking infrastructure for electrical bicycles, including (electric-) cargo- bikes, and for special vehicles of people with reduced mobility
- requirements related to smart/intelligent metering
- requirements related to smart charging
- requirements which would facilitate the use of car batteries as a source of power (vehicle to grid)
- for publicly accessible recharging points, requirements related to ad hoc recharging and transparency of recharging prices

MS have chosen to a varying degree to implement these additional measures. For instance, two MS (Austria and Romani) have incorporated references to cycling in the EPBD implementing legislation. France has implemented fire safety regulations.

5. Policy options for e-mobility

The requirements present in the EPBD since its 2016 revision are not fit anymore to provide a number of recharging points aligned with an increased uptake of electric vehicles, as the requirements are too low because they only cover buildings with more than 10 parking spaces.

Table I.1: E-mobility policy options

C1. Remove building-related barriers to e-mobility			
No.	**Policy action - general**	**Timeline**	**Sub-options**
E-M1	All new buildings or major renovations have to be prepared for electric recharging	MS to implement by 2025	• Preparedness via pre cabling, but reducing from 10 to 5 (or lower) the minimum number of parking spaces triggering the obligation • Pre-cabling to be "smart-ready"
E-M2	All new buildings or major renovations have to be prepared for electric recharging + measures to enhance "Right to plug"	MS to implement by 2025	As in E-M1+ MSs to implement right to plug : • MS shall remove barriers that hinders e-vehicle owners to have access to a recharging point in parking adjacent to buildings (multi-family residential buildings or rented single family buildings mainly)[181] • Enhance availability of technical assistance for households wishing to install recharging points
E-M3	As in E-M2+ bike parking Additional measures for non-residential buildings	MS to implement by 2025	As in E-M2+ • Compulsory bike parking in new and major renovated buildings • Existing non-residential buildings with more than 20 parking spaces at least 10% equipped with recharging points by 2027 • Increased ambition for number of recharging points in new and major renovated office buildings

Policy option E-M1 enlarges the scope of the current provisions to ensure preparedness to electric recharging for all new buildings and buildings undergoing major renovation. This is a cost-effective measure and it ensures the building's parking spaces are ready,

[181] There is an example in the US "Right to Charge" law which requires building owners to allow tenants to install EV recharging points if they want to. The Massachusetts Legislature passed a "Right to Charge" law, which requires building owners in Boston to allow tenants to install EV charging if they want to. Session Law - Acts of 2018 Chapter 370 (malegislature.gov)

when and if the need arises, for the installation of recharging points. The threshold is lowered from 10 parking spaces to 5 parking spaces (or lower) which significantly enhances the number of parking places prepared for electric recharging.

One option is to strengthen the requirement even further and remove the threshold of number of parking spaces for new construction. This would mean that preparedness is required for all new construction with parkings, independently on how many parking spaces (i.e also newly constructed single-family house with one parking would have to be prepared for e-vehicles).

In addition, the current EPBD Article 8(3) requires that Member States lay down requirements for the installation of a minimum number of recharging points for certain non-residential buildings with more than 20 parking spaces. Article 8(2) mandates the installation of recharging points (one in every ten parking spaces) and ducting infrastructure (one in every five parking spaces) in the car parks of non-residential buildings with more than 10 parking spaces. This provision applies to all new non residential buildings and major renovations.

The reason why the policy option for residential buildings requires preparedness and not the installation of the specific recharging point is to avoid costs for infrastructure which may be not used, especially in residential buildings where the take-up is difficult to estimate. Moreover different owners and tenants may have different needs and desires, e.g. in terms of max delivered power or of smartness of the charging station. Finally, some vehicle offers include the provision of a fixed charging station (on top of the mobile one, usually provided). The aim is to ensure that recharging stations are installed when they are needed. If there would be a requirement to install a recharging station in a residential building where it is not needed at a certain moment, it would entail additional costs and there is a risk that the recharging station would be obsolete or out of order/damaged before it is needed.

In the public consultation respondents were asked if there was a need to strengthen the existing provisions on e-mobility in the EPBD. For new buildings (non-residential and residential) 60% see a need for strengthening the requirements. For refurbished buildings, 53% (non-residential) and 49% (residential buildings) see a need for strengthening the requirements. Some stakeholders also suggested that there should be requirements for all buildings to be pre-equipped for recharging.

One MS that has already strengthened the e-mobility provisions is Finland. New legislations introduced 11 November 2020, which state for residential buildings (new and buildings undergoing major renovations) for areas with more than 4 parking spaces they must all have electric conduits (or cables) for all parking spaces. For the new building and major renovation is in effect from 11 March 2021, when building permits are requested. Existing buildings have to have charging points installed by 31st December 2024. It is estimated that 73,000 – 97,000 new charging points and 560,000–620,000 parking spaces with electric ducts or cables by the year 2030. The requirements are not applied to buildings owned and occupied by micro-sized enterprises (<10 employees), this differs from the directive where this exemption is for SME. For residential buildings, Finland is more ambitious than the Directive in that it has set requirements for electric conduits (or cables) for all parking spaces on buildings with more than 4 parking spaces.

To enhance the "right to plug", **E-M2** foresees that barriers are removed and measures are undertaken to enhance the availability of technical assistance for households wishing to install recharging points. The aim is to guarantee for owners and tenants smooth and quick approval procedures to install recharging points in existing multi-tenant residential and non-residential buildings.

Article 8(7) of the EPBD requires Member States to provide for measures to simplify deployment of recharging points in new and existing residential and non-residential buildings and to address possible regulatory barriers, including permitting and approval procedures. This obligation must be fulfilled by transposing the EPBD into national legislation by the transposition deadline at the latest. This provision is however deemed not enough to remove the administrative barriers encountered, especially in multi-family buildings.

Lengthy and complex approval procedures can be a major barrier to owners and tenants installing recharging points in existing multi-tenant residential and non-residential buildings. For instance in properties under shared ownership such as condominiums the installation of recharging stations in some cases require the agreement of all co-owners and in others the majority of the assembly[182].

There are examples in several countries such as Spain, the Netherlands and Norway of legislations to ensure the "right to plug". See below for more details.

Obtaining the necessary approvals can create delays or prevent installation. 'Right to plug' or 'right to charge' requirements ensure that any tenant or co-owner is able to install a recharging station without prior (potentially difficult) consent from the landlord or from the other co-owners. In Spain and Italy, for example, legislation allows a co-owner to install a recharging point for private use when located in an individual parking place and when the association of co-owners has been informed in advance. The co-owners cannot block the installation. The cost of the installation and of the subsequent electricity consumption is assumed by the individual who has installed the recharging point. Only installation in a common area requires prior approval by the assembly.

In the public consultation, 62% of respondents suggested to introduce a right to plug in multi-dwelling buildings. The right to plug should ensure the right for owners/occupants of apartments to install a recharging point for their parking spot in a shared parking. Some respondents also suggested that the right to plug should apply to non-residential

[182] Usually meeting once a year.

buildings. Some stakeholders raised concerns as to the readiness of the grid for the recharging points and the large investment needs.

However, as regards administrative barriers, only one third of respondents reported that they were aware of administrative barriers preventing the deployment of charging points in their country.

E-M3 extends the readiness also to parking space for bikes, including e-scooters and e-bikes[183].[184] In the public consultation, 52% of respondents suggested the inclusion of provisions for vehicles other than cars. In the current EPBD, there are no requirements to provide recharging for e-bikes, however recital 28 and Article 8.8 refers to e-bikes in the requirement for MS to consider the need for dedicated parking infrastructure for electric bicycles and to consider the need for coherent policies for buildings, soft and green mobility and urban planning[185].

Recharging for e-bikes is different from recharging for electric cars as the battery can easily be removed from the bike and be recharged at another location than the parking (also, many e-bike owners prefer to remove the battery to minimise the risk for theft). Also, the e-bike can be charged in a normal socket, a specific recharger is not needed. However a problem for many e-bike owners, especially in city centres, is access to a safe bike parking. In the context of the EPBD, the main avenue for promoting sustainable transport and emission reductions through e-bikes would be to require bike parkings in building codes. Updating parking norms to also cater for electric bikes, eventually using car stalls, would be a step in promoting sustainable infrastructure and emissions reduction and air quality, health and congestion in urban areas.

The suggested policy option in the EPBD is a requirement for MS to introduce minimum bicycle parking requirements in new buildings and buildings undergoing major renovation (residential and non-residential). The level of ambition should be at least one bike park per dwelling for residential buildings. For non-residential at least one bike park for every car parking space.

For major renovation the number of bike parking spaces can be increased through the conversion of car parkings to bike parkings. Examples from MS include the Bulgarian

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[183] The private bicycle as well as private e-bike are the most energy-efficient of all vehicles, both for vehicle-km as well as person-km (International Transport Forum (ITF) 2019: Lifecycle Assessment of Emerging Urban Transport Business Models)

[184] An estimated 5.1 million e-bikes were sold in the EU-27 in 2020, bringing total stock to about 20 million e-bikes in the EU. (https://www.ziv-zweirad.de/uploads/media/PM_2021_10.03._ZIV-Praesentation_10.03.2021_mit_Text.pdf)

The European bicycle industry forecasts strong growing demand for e-bikes over the next decade and will reach annual sales of 17 million units in 2030. (New European Cycling Industry Forecast shows huge growth in bike and e-bike sales | Cycling Industries Europe - The voice of cycling businesses in Europe)

[185] Incorporating electromobility early in the development of mobility plans adopted under SUMP can help to realise the objectives of Article 8(8) of the EPBD.

Regulation for bike parking, requiring 1,5 spaces per household in multifamily residential buildings

Large non-residential buildings, such as offices and workplaces, will be key for the uptake of evehicles, as they give the opportunity to charge during the day at the workplace. For this category of buildings, the proposal is to include a requirement for existing buildings to equip at least 10% of parking places in 2027 with recharging stations. The requirement will apply to existing non-residential buildings with more than 20 parking places. In the existing EPBD there is already a requirement for MS to set out requirements for the installation of a minimum number of recharging stations in this category of buildings. The suggested policy option is strengthening the existing requirement.

6. Estimation of impacts and costs

In the Fit for 55 Mix-scenario, the total cost for the electricity recharging infrastructure in the EU is estimated to EUR 31,6 billion for the period 2026-2030 and EUR 69,5 billion for the period 2046-2050. This is the total amount, including accessible both publicly available and private infrastructure.

In order to assess the impact of the proposed policy options E-M1 to E-M3 for electro mobility the following table shows the differences between the current EPBD and the proposed options.

Table I.2: E-mobility policy options – comparison with current requirements

Building type	Current EPBD	E-M1	E-M2 and E-M3
Residential Buildings	New and major renovation with more than 10 parking spaces[186]: Ducting infrastructure for every parking space	All new and major renovation with more than 5 parking spaces: Precabling	E-M1 plus MS implement "Right to plug" and therefore trigger more purchases of recharging points in residential buildings (assumption 20% by 2050, especially SMFH)
Non-residential Buildings	New and major renovation with more than 10 parking spaces[187]: 1. ≥ 1 recharging point 2. Ducting infrastructure for ≥ 1/5 of the parking spaces		
	All non-residential buildings with more than 20 parking spaces[188]: by 2025: Minimum number of recharging points to be defined by MS		All non-residential buildings with more than 20 parking spaces:

[186] EPBD Article 8(5)
[187] EPBD Article 8(2)
[188] EPBD Article 8(3)

			by 2027: Recharging points for 1/10 of all parking spaces

Therefore, the differences between a) numbers of parking spaces with recharging points and ducting infrastructure for the proposed policy options, and b) numbers incurred by the current EPBD need to be evaluated to quantify the impacts of the policy option. To determine these differences, estimations on the total number of parking spaces in Europe and additional assumptions (e.g. the shares of buildings per building type with more than 10 parking spaces or the average major renovation rates) is needed.

Estimation of the number of parking spaces in Europe

The following table reflects the space floor area development by building categories.

Table I.3: Floor Area (per building type) in million square meters[189]

Building type	2020	2025	2027	2030	2050
SFH	11,060	11,427	11,577	11,808	13,495
SMFH	2,929	3,010	3,043	3,093	3,459
LMFH	3,818	3,934	3,982	4,055	4,594
OFB	1,501	1,574	1,605	1,653	2,026
TRB	1,486	1,561	1,593	1,642	2,029
EDB	1,111	1,169	1,193	1,230	1,527
TOB_HEB	1,304	1,365	1,390	1,429	1,728
ONB	905	950	968	997	1,225

To convert these values into a number of parking spaces, additional assumptions must be taken as regards the number of parking spaces per unit of floor area. For this purpose, it is assumed:

- 1.25 parking spaces/100m² (1 parking space per household of 80m² on average) in residential buildings;
- 1.00 parking space/100m² in non-residential buildings.

As the different options and the current EPBD apply for buildings with parking areas with more than 5, 10 and 20 parking spaces, assumptions must be taken in this respect. For residential buildings, the distribution directly results from the residential buildings' sub categories. For non-residential, assumptions in were established based on the reference building cases taken for each sub-category. For example the representative building for "Education" (EDB) and "Touristic and Health" (TOB_HEB) is well above

[189] Source: Guidehouse et al.

1,000m² and therefore is assumed a higher share of such buildings being above 5, 10 or 20 parking spaces.

Average renovation rates[190] were also assumed to observe what share of the 2020 existing stock would be covered by the application to the major renovation[191] clause.

Table I.4: Additional assumptions

Building type	Number of parking space for 100m²	Share of buildings with more than 5 parking space	Share of buildings with more than 10 parking space	Share of buildings with more than 20 parking space[192]	Average major renovation rate[378]
SFH	1.25	0%	0%	0%	1.50%
SMFH	1.25	50%	0%	0%	1.50%
LMFH	1.25	100%	100%	50%	1.50%
OFB	1.00	75%	50%	25%	2.70%
TRB	1.00	75%	50%	25%	2.70%
EDB	1.00	90%	75%	38%	2.70%
TOB_HEB	1.00	90%	75%	38%	2.70%
ONB	1.00	75%	50%	25%	2.70%

This set of assumptions allows the determination of the number of parking spaces for different cases as reflected in the table below. Between 2020 and 2050:

- 83.1 million parking spaces in new buildings would be constructed (27.9 million in parking areas with more than 10 parking spaces),
- 190.3 million parking spaces would be located in building that undergo a major renovation (67.0 million in parking areas with more than 10 parking spaces),
- 81.3 million parking spaces would remain unchanged.

Table I.5: Number of parking spaces (in million units) by cases, cumulated between 2020 and 2050

	In buildings with less than 10 parking spaces	In buildings with more than 10 parking spaces	In buildings with more than 20 parking spaces	All
New buildings (between 2020 and 2050)	55.2	27.9	(13.9)[193]	**83.1**
Major renovations (between 2020 and 2050	123.3	67.0	(33.5)	**190.3**

[190] Following Esser et al., 2019 (assumption for major renovations = deep renovations + medium renovations/2; reason: only half of the medium renovations will qualify as major renovation)

[191] Major renovation in the context of Article 8 of the EPBD proposal is as defined in Article 2(10) of the EPBD.

[192] Assumption: Share of buildings with more than 20 parking space = 50%* Share of buildings with more than 10 parking space.

[193] Subset of more than 10 parking spaces but needed for the determination of the recharging points for the current EPBD variant

Others	67.9	13.4	(6.7)	**81.3**
Total	**246.5**	**108.2**	**(54.1)**	**354.7**

Estimation of the number of recharging points and ducting infrastructure in Europe

The below table shows the results for the differences of recharging points and ducting infrastructure/pre-cabling of the proposed policy options compared to the current EPBD as described above.

Table I.6: Difference of number of recharging points and ducting infrastructure (in million units) by cases to current EPBD, cumulated between 2020 and 2050

Building category		E-M1	E-M2 and E-M3
Residential Buildings	Recharging points	0.0	10.2
	Ducting infrastructure/ pre-cabling	13.8	13.8
Non-Residential Buildings	Recharging points	0.0	3.9
	Ducting infrastructure/ pre-cabling	4.1	4.1

In E-M1 the number of parking spaces with ducting infrastructure is estimated to increase by roughly 18 million compared to the current EPBD until 2050 (13.8 in/adjacent to residential and 4.1 in/adjacent to non-residential buildings), which is due to obliging significantly more smaller buildings to have ducting infrastructure, too. E-M2 and E-M3 do not pose additional requirements for ducting infrastructure, which keeps those 18 million unchanged.

While E-M1 does not require to add recharging points, the 'right to plug' required in E-M2 and E-M3 will motivate and enable owners and tenants, especially in multi-family buildings, to actually use the ducting infrastructure for installing a recharging point.

As illustrated in the above tables, it is assumed that 20% of all parking spaces with ducting infrastructure (especially in SMFH) will be used for installing a recharging point. This adds another roughly 10 million recharging points in residential buildings compared to the current EPBD.

Also in E-M3, for existing non-residential buildings with more than 20 parking spaces, it requires that 1 in 10 parking spaces should be equipped with a recharging point from 2027 on, and 2 in 10 from 2030 on. For 2050 a share of 3 in 10 is assumed.

Compared to current EPBD requirements this adds roughly 4 million recharging points.

Estimation of costs

The total CAPEX of a Type2 smart 22kVA charging point can be estimated around €2,500/unit[194]. This cost includes the full installation (cabling and recharging point itself) assuming simple configurations (no structural work, i.e. no drilling of walls or slabs). These cost estimates are valid for indoor recharging points (outdoor recharging points are typically more expensive).

Table I.7: Difference of costs for recharging points and pre-cabling (in billion Euros) by cases, cumulated between 2020 and 2050

	E-M1	E-M2 and E-M3
Recharging points	0	35,326
Precabling	8,923	8,923

E-M1 creates additional pre-cabling infrastructure in both residential and non-residential buildings, creating an additional investment need of approximately EUR 9 billion until 2050.

As described above, E-M2 and E-M3 will create additional recharging points in residential buildings and in non-residential buildings, with an estimated EUR 35 billion of investment until 2050.

7. Experiences in Member States on "right to plug"

Several countries have implemented some sort of Right to Plug in their national legislations:

Spain

Ley de Propiedad Horizontal art. 17.5): "The installation of an electric vehicle recharging point for private use in the building's car park, provided that it is located in an individual garage space, will only require prior communication to the community. The cost of said installation and the corresponding electricity consumption will be fully assumed by the direct interested party (s)."

France

Code of Construction and Housing (Code de la construction et de l'habitation)

[194] The pre-cabling infrastructure can be assumed at 500 €.

- Article L.111-6-4 provides that a community of owners may not oppose the equipment of private parking spaces with charging equipment for electric or plug-in hybrid vehicles, without serious and legitimate reasons.

- Article L. 111-6-5 specifies the conditions for the installation, management and maintenance of electric charging equipment within a multi-unit building and serving one or more end-users.

Decree 873 of 2011 outlines the terms of application of these two articles. The owner is required to request the approval of the Community of Owners.

- If the request is rejected, the Community of Owners has 6 months after receiving the approval request to bring it before a judge. If the request is not brought before a judge within 6 months, the owner can install the charging equipment.

- If the request is reviewed by a judge, it may only be rejected is there are serious motives, e.g. if the installation represents the "execution of impossible work" (*exécution des travaux impossibles*).

Portugal

Property Law:

- In order to install a charging station the condominium administration must be contacted at least 30 days prior in according to Decree Law n.º90/2014 Article 26/29 (Decreto Lei n.º90/2014), which alters Decree Law n.º39/2010 (Decreto Lei n.º39/2010)

- Any condominium member, tenant or legal occupier may install, at their own expense, charging points for electric vehicle batteries or electrical outlets that meet the technical requirements defined by the DGEG (DGEG).

- Opposition by the administration is possible if a charging station is already installed or planned in the next 90 days or if it causes safety risks to persons or property or harms the architectural line.

- New buildings or rebuilt buildings are required to have a charging point or electrical outlet at parking spaces.

Italy

Il Vademecum per le Ricariche Condominali e Private :

> "1) If you have a private parking space it is necessary to distinguish how the electricity supply takes place: a) By installing a electricity meter in the name of that neighbour, a written communication to the administrator of condominium which will have to take act of the decision taken since not special authorizations

are required. The works must be carried out in accordance with the technical regulations."

There is also a regulation that states that a co-owner has to ask the assembly (if there are shared costs). If the assembly refuses or if no answer is given within 3 months, the owner has the right to install the station at his/her own expenses.[195]

Netherlands

The Dutch government is preparing a legislative proposal to implement Right to Plug. Letter from the Government to the Parliament with the formal announcement (in English).

In addition, as regards experiences outside the EU, In Norway the right to plug is legislated for condominiums and owner-owned properties[196]: § 25a i eierseksjonslove and § 5-11 a i borettslagsloven. There is also technical support available to support the recharging installation process in multi-family buildings, covering the following aspects:

- Own or rent the recharging infrastructure?
- Costs (investment and operational)
- Future-proof technologies
- Ensure enough power-supply to the building
- How to handle existing rechargers
- Legal aspects
- Payment solutions
- Maintenance and support
- The need for fast chargers

8. Fire safety concerns in in-door car parkings

Some stakeholders, including in the public consultation, have put forward fire safety concerns related to parking of EVs in underground car parks. Although electric cars do not catch fire more frequently than conventional vehicles, they behave differently in the event of fire. A great deal of water is needed to extinguish the fire, and the cells in the battery packs can reignite hours or days later. The fire brigade therefore uses special water containers in which electric cars are immersed. However, these do not fit into all

[195] DECRETO LEGISLATIVO 16 dicembre 2016, n. 257
[196] § 25a i eierseksjonslove and § 5-11 a i borettslagsloven

underground or multi-storey car parks. In addition, the chemical fire of a battery releases toxic gases and generates such extreme heat that reinforced concrete can burst and iron can melt, leading to the risk of the structure collapsing.

There are local examples, for instance in Germany (Kulmbach, Leonberg), where the use of city-owned underground car parks is prohibited for electric vehicles. Also, in the opinion of the German Fire Prevention Association (Vereinigung zur Förderung des Deutschen Brandschutzes – VFDB), such fires do indeed bear 'significant potential risks'.

There are no policy options foreseen in the EPBD revision that addresses fire safety of electric vehicles in underground parks, as this would be mainly within the competence of national administrations. In an EU context, but outside the scope of the EPBD, one option could be to develop European recommendations for the fire-safe deployment of recharging points in buildings, to be developed together with European fire brigade associations. Another could be to allocate specific funds to better training and equipping fire brigades in Europe to deal with these kinds of problems (e.g. procuring specialised towing equipment, to tow extreme heated EVs after a fire out of an underground garage).

The Commission has been for years actively involved in the work of technical experts related to the safety of electric vehicles. Rules are already in place[197] and are relevant for EU type approval of vehicles. The Commission will continue its work on the international harmonisation of technical requirements in UNECE[198], thus further improving the safety of electric vehicles and will remain actively involved in the activities of international and European standardisation organisations, with a particular focus on the charging interfaces for electric vehicles. Also, the Batteries Partnership will make significant efforts to further address safety concerns for battery systems[199].

As regards the handling of fires, the adoption of potential fire safety guidelines related to electric vehicle fires remains the responsibility of national, regional and local fire and rescue services and associations. The International association of fire and rescue services (CTIF200) regularly organises seminars and trainings for first and second responders as regards the handing of electric vehicles. A number of reports201 contain information on fire safety of parking garages with electric vehicles.

[197] E /ECE/324/Rev (unece.org)
[198] United Nations Economic Commission for Europe
[199] The objective of the partnership to be launched under Horizon Europe is to develop different monitoring features for current generations of batteries (embedded sensors to monitor the state of health and isolation of defective cells, advanced cooling systems preventing thermal runaway…), as well as to develop inherently safer and more robust solid-state batteries.
[200] https://www.ctif.org/index.php/
[201] An example worth mentioning is a recent report published by the Dutch Institute for Safety (Het Instituut Fysieke Veiligheid (IFV)) on fire safety of parking garages with electrically-propelled vehicles (20201208-IFV-Brandveiligheid-parkeergarages-met-elktrisch-aangedreven-voertuigen.pdf).

Annex J: Climate Target Plan Policy Conclusions

1. 2030 CLIMATE TARGET PLAN POLICY CONCLUSIONS

The Communication on stepping up Europe's 2030 climate ambition - the Climate Target Plan (CTP)[202] and its underpinning impact assessment are the starting point for the initiatives under the Fit for 55 package.

The plan concluded on the feasibility - from a technical, economic and societal point of view - of increasing the EU climate target to 55% net reductions of greenhouse gases (GHG) emissions by 2030 compared to 1990. It also concluded that all sectors need to contribute to this target.

In particular, with energy supply and use responsible for 75% of emissions, the plan put forward ambition ranges for renewables and energy efficiency, which correspond in a cost-efficient manner to the increased climate target. The CTP also established that this increase in climate and energy ambition will require a full update of the current climate and energy policy framework, undertaken in a coherent manner.

As under the current policy framework, the optimal policy mix should combine, at the EU and national levels, strengthened economic incentives (carbon pricing) with updated regulatory policies, notably in the field of renewables, energy efficiency and sectoral policies such as CO_2 standards for new light duty vehicles. It should also include the enabling framework (research and innovation policies, financial support, addressing social concerns).

While sometimes working in the same sectors, the policy tools vary in the way they enable the achievement of the increased climate target. The economic incentives provided by strengthened and expanded emissions trading will contribute to the cost-effective delivery of emissions reductions. The regulatory policies, such as the Renewable Energy Directive (RED), the Energy Efficiency Directive (EED), the Regulation on CO_2 standards for vehicles supported by the Directive on the alternative fuels infrastructure, and the Re(FuelEU) aviation and maritime initiatives, aim at addressing market failures and other barriers to decarbonisation, but also create an enabling framework for investment, which supports cost-effective achievement of climate target by reducing perceived risks, increasing the efficient use of public funding and helping to mobilise and leverage private capital. The regulatory policies also pave the way for the future transition needed to achieve the EU target of the climate neutrality. Such a sequential approach from the CTP to the Fit for 55 initiatives was necessary in

[202] COM (2020) 562 final.

order to ensure coherence among all initiatives and a collective delivery of the increased climate target.

With the "MIX" scenario, the impact assessment included a policy scenario that largely reflects the political orientations of the plan.

The final calibration between the different instruments is to be made depending, *inter alia* on the decision on the extension of emissions trading beyond the maritime sector and its terms.

The table below shows the summary of the key CTP findings:

Table J.1: Key policy conclusions of the CTP

POLICY CONCLUSIONS IN THE CTP	
GHG emissions reduction	• At least 55% net reduction (w.r.t. 1990) • Agreed by the European Council in December 2020 • Politically agreed by the European Council and the European Parliament in the Climate Law
ETS	• Corresponding targets need to be set in the EU ETS and the Effort Sharing Regulation to ensure that in total, the economy wide 2030 greenhouse gas emissions reduction target of at least 55% will be met. • Increased climate target requires strengthened cap of the existing EU ETS and revisiting the linear reduction factor. • Further expansion of scope is a possible policy option, which could include emissions from road transport and buildings, looking into covering all emissions of fossil fuel combustion. • EU should continue to regulate at least intra-EU aviation emissions in the EU ETS and include at least intra-EU maritime transport in the EU ETS. • For aviation, the Commission will propose to reduce the free allocation of allowances, increasing the effectiveness of the carbon price signal in this sector, while taking into account other policy measures.
ESR	• Corresponding targets need to be set in the Effort Sharing Regulation and under the EU ETS, to ensure that in total, the economy wide 2030 greenhouse gas emissions reduction target of at least 55% will be met.
LULUCF	• Sink needs to be enhanced. • Agriculture forestry and land use together have the potential to become rapidly climate-neutral by around 2035 and subsequently generate removals consistent with trajectory to become climate neutral by 2050.
CO2 standards for cars and vans	• Transport policies and standards will be revised and, where needed, new policies will be introduced. • The Commission will revisit and strengthen the CO_2 standards for cars and vans for 2030. • The Commission will assess what would be required in practice for this sector to contribute to achieving climate neutrality by 2050 and at what point in time internal combustion engines in cars should stop coming to the

	market.
Non-CO2 GHG emissions	• The energy sector has reduction potential by avoiding fugitive methane emissions. The waste sector is expected to strongly reduce its emissions already under existing policies. Turning waste into a resource is an essential part of a circular economy. Under existing technology and management options, agriculture emissions cannot be eliminated fully but they can be significantly reduced while ensuring food security is maintained in the EU. Policy initiatives have been included in the Methane Strategy.
Renewables	• 38-40% share needed to achieve increased climate target cost-effectively. • Renewable energy policies and standards will be revised and, where needed, new policies will be introduced. • Relevant legislation will be reinforced and supported by the forthcoming Commission initiatives on a Renovation Wave, an Offshore Energy strategy, alternative fuels for aviation and maritime as well as a Sustainable and Smart Mobility Strategy. • EU action to focus on cost-effective planning and development of renewable energy technologies, eliminating market barriers and providing sufficient incentives for demand for renewable energy, particularly for end-use sectors such as heating and cooling or transport either through electrification or via the use of renewable and low-carbon fuels such as advanced biofuels or other sustainable alternative fuels. • The Commission to assess the nature and the level of the existing, indicative heating and cooling target, including the target for district heating and cooling, as well as the necessary measures and calculation framework to mainstream further renewable and low carbon based solutions, including electricity, in buildings and industry. • An updated methodology to promote, in accordance with their greenhouse gas performance, the use of renewable and low-carbon fuels in the transport sector set out in the Renewable Energy Directive. • A comprehensive terminology for all renewable and low-carbon fuels and a European system of certification of such fuels, based notably on full life cycle greenhouse gas emissions savings and sustainability criteria, and existing provisions for instance in the Renewable Energy Directive. • Increase the use of sustainably produced biomass and minimise the use of whole trees and food and feed-based crops to produce energy through inter alia reviewing and revisiting, as appropriate, the biomass sustainability criteria in the Renewable Energy Directive,
Energy Efficiency	• Energy efficiency policies and standards will be revised and, where needed, new policies will be introduced. • Energy efficiency improvements will need to be significantly stepped up to around 36-37% in terms of final energy consumption[203].

[203] The Impact Assessment identifies a range of 35.5% - 36.7% depending on the overall design of policy measures underpinning the new 2030 target. This would correspond to a range of 39.2% - 40.6% in terms of primary energy consumption.

	• Achievement of a more ambitious energy efficiency target and closure of the collective ambition gap of the national energy efficiency contributions in the NECPs will require actions on a variety of fronts. • Renovation Wave will launch a set of actions to increase the depth and the rate of renovations at single building and at district level, switch fuels towards renewable heating solutions, diffuse the most efficient products and appliances, uptake smart systems and building-related infrastructure for charging e-vehicles, and improve the building envelope (insulation and windows). • Action will be taken not only to better enforce the Energy Performance of Buildings Directive, but also to identify any need for targeted revisions. • Establishing mandatory requirements for the worst performing buildings and gradually tightening the minimum energy performance requirements will also considered.

Annex K: The EPBD and its linkages with other instruments and policies

1. The EPBD revision in the Renovation Wave Action Plan

The Renovation Wave communication integrates climate, energy and environmental objectives, industrial strategy and circularity objectives, as well as skills, consumer welfare and fair and social transition goals. It links with ongoing work on green finance and sustainable investments and includes targeted actions at EU, national and local level. It focuses especially on tackling energy poverty and worst-performing buildings, on renovating public buildings and social infrastructure and on decarbonising heating and cooling. The holistic approach to building renovations outlined by the Renovation Wave can open up numerous possibilities and generate far-reaching social, environmental and economic benefits. With the same intervention, buildings can be made healthier, greener, interconnected within a neighbourhood district, more accessible, resilient to extreme natural events, and equipped with interoperable, standardised recharging points for e-mobility and bike parking.

To achieve its far-reaching and holistic ambitions, the Renovation Wave has identified 23 implementation action points, including regulatory measures as well as financing and supporting actions. The current EPBD revision addresses 3 of the 23 key Commission actions to implement the Renovation Wave and some of its main regulatory measures. This entails the introduction of mandatory minimum energy performance requirements for buildings (MEPS), and the revision of the EPCs framework, the proposal to introduce building renovation passports (BRPs) and to consider the introduction of a deep renovation standard. Other regulatory and supporting measures for the implementation of the Renovation Wave are being addressed by strengthening of the EU legislative framework of the Energy Efficiency Directive (EED), the Renewable Energies Directive (RED), Ecodesign Directive and Energy Labelling Regulation, as well as by the New European Bauhaus initiative[204].

Here below is an overview of the Renovation Wave Action Plan as published on 14 October 2020:

[204] Established to ideate, incubate, accelerate and realise innovative projects demonstrating the right balance of sustainability (comprising circularity), quality of life (comprising aesthetic) and inclusion (comprising accessibility and affordability), the New European Bauhaus is called to support the objectives of the Renovation Wave while going beyond buildings. Form will follow Planet, making the necessary beautiful too in a more sustainable and just built environment.

Strengthening information, legal certainty and incentives for renovation	
Revision of **Energy Performance Certificates** and proposal to introduce **mandatory minimum energy performance standards** for all types of buildings in the EPBD	2021
Revision of requirements on **energy audits** in the EED	2021
Proposal on **Building Renovation Passports** and introduction of **a single digital tool** unifying them with Digital Building Logbooks	2023
Developing a **2050 whole life-cycle performance roadmap** to reduce carbon emissions form buildings and advancing national **benchmarking** with Member States	2023
Reinforced, accessible and more targeted funding supported by technical assistance	
Proposed **strengthened financing for the ELENA** facility from the InvestEU advisory hub and possibly from other European programmes	2021
Consider the introduction of a **'deep renovation' standard** as part of the EPBD revision	2021
Revising the **climate-proofing guidelines** for projects supported by the EU	2021
Supporting **de-risking energy efficiency investments**, and proposing to incorporate **environmental, social and governance (ESG) risks** into the Capital Requirements law and the Solvency II Directive	2021
Reviewing the **General Block Exemption Regulation and Energy and Environmental Aid Guidelines**	2021
Creating green jobs, upskilling workers and attracting new talent	
Supporting Member States to update their national roadmaps for the training of the construction workforce through the **Build Up Skills** Initiative and helping implement the 2020 **European Skills Agenda**	2020
Sustainable built environement	
Reviewing **material recovery targets** and supporting the internal market for secondary raw materials	2024

Presenting a **unified EU Framework for digital permitting** and recommending **Building Information Modelling** in public procurement	2021
Supporting **digitalisation in the construction sector** through Horizon Europe, Digital Innovation Hubs and Testing and Experimentation Facilities	2021
Placing an integrated participatory and neighbourhood based approach at the heart of renovation	
Setting up a creative **European Bauhaus** platform to combine sustainability with art and design	2020
Supporting sustainable and decarbonised energy solutions through **Horizon Europe** and the **R&I co-creation space**	2020
Facilitating the development of **energy communities** and **local action** through the European Smart Cities Marketplace	2020
Supporting the development of **climate-resilient building standards**	2020
Tackling energy poverty and worst-performing buildings	
Launching the **Affordable Housing Initiative** piloting 100 renovation districts	2021
Public buildings and social infrastructure showing the way	
Proposing to extend the **requirements for renovation to buildings** in the EED **to all public administration levels**	2021
Based on Level(s), developing **green public procurement criteria related to life cycle and climate resilience** for certain public buildings	2022
Decarbonising heating and cooling	
Developing **ecodesign and energy labelling** measures	2020
Assessing the **extension of the use of emission trading to emissions from buildings**	2021
Revising the RED and the EED and considering strengthening the **renewable heating and cooling target** and introducing a requirement for **minimum proportions of renewable energy in buildings**. Also facilitating access of **waste and renewable heat and cool into energy**	2021

systems	

2. Interactions with the key ‘Fit for 55’ legislation/initiatives

Achieving at least 55% net greenhouse gas (GHG) emission reductions by 2030 compared to 1990 at an economy wide scale require a significant scale up of ambition of all relevant policy instruments – as analysed in the CTP.

Because by far most GHG emissions originate in the energy system[205] (including end-use sectors such as transport, buildings and industry), an enhanced energy policy framework, addressing energy efficiency (EE) and renewable energy (RES) is key to achieve the climate target in a cost-efficient manner in addition to contributing to other European Green Deal objectives. The need for increased ambition, addressing identified weaknesses and intensifying the relevant measures has guided the preparation of the proposals included in the first “Fit for 55” package adopted in July 2021, while the EPBD revision and other reforms have been planned for adoption at a later stage. This approach avoids the risk of incoherence or regulatory overshoot with the initiatives.

The current EU climate and energy policy framework already presents several elements of synergies. Energy efficiency and renewable energy policy both reduce fossil fuels use and thus are strong drivers for GHG emissions reduction. The existing mix represents a combination of regulatory policies and economic incentives, as well as other enabling conditions such as research and innovation or financing and also strategic planning instruments such as NECP and LTRS. In developing the current policy framework, the complementarity of the instruments has been ensured.

The “Fit for 55” package has been outlined to ensure an optimal policy mix, addressing in a targeted manner market failures and non-market barriers, following the indications provided in the Climate Plan which highlighted the need for a mix of instruments to achieve the goal of reducing GHG emissions by -55% by 2030 in comparison to 1990 levels. It also provides economic incentives to take action. The approach proposed in the F55 is to deploy various complementary policy instruments to address distinct challenges in the pursuit of climate neutrality.

The proposals to review the REDII and EED aim at creating an enabling framework for investment which supports cost-effective achievement of the climate and energy targets by reducing perceived risks, increasing the efficient use of public funding and helping to mobilise and leverage private capital. Both the investment challenge and fairness

[205] Based on the analysis underpinning the Climate Target Plan, around 75 % of the GHG emissions are related to energy production and use.

considerations are also captured in the EU budget with the requirement that at least 30% of the expenditure under the Multiannual Financial Framework 2021-2027 and 37% of the NextGenerationEU Recovery Instrument support climate objectives. The appropriate use of these resources will contribute to spur the transition to climate neutrality.

Moreover, the Effort Sharing Regulation (EU) 2018/842[206] supports the implementation of the Renovation Wave strategy, as it sets binding GHG emission reduction targets for Member States covering several sectors, including the building sector.

The EPBD revision in turn addresses the specific and mainly non-economic barriers that prevent the energy renovation of buildings at a scale, speed and depth which would be sufficient to achieve the GHG reduction goal of -55% by 2030. It introduces specific standards for new and existing buildings, requirements for certain buildings and information tools to ensure that the finance available for renovation achieves maximum results and benefits, enhancing the price signal from ETS.

2.1. Interactions with the legislation on energy efficiency, renewables and the hydrogen and Gas markets Decarbonisation Package

The **Energy Efficiency Directive** (EED), adopted in 2012 and last amended in 2018 by means of Directive (EU) 2018/2002, establishes a common framework of measures for the promotion of energy efficiency within the EU, in view of achieving the Union's headline targets on energy efficiency. The energy efficiency target for 2030 amount to a reduction of final and primary energy consumption of -32.5% by 2030 in comparison to scenario projections. The EED includes horizontal provisions to promote energy efficiency across the economy. As regards the provisions most relevant for the buildings sector, under the EED EU countries must make energy efficient renovations to at least 3% of the total floor area of buildings owned and occupied by central governments each year. In addition, national governments shall only purchase buildings that are highly energy efficient, where this is cost-efficient and feasible. There is a strong interaction with the EPBD because the standards on new buildings and energy renovations set in the EPBD contribute to the energy savings in the building sector which are necessary to achieve the 2030 goals set in the EED. The sectoral measures on buildings also include information tools, technical inspections and requirements in relation to finance instruments, which all are enablers removing specific barriers preventing energy efficiency gains in the building sector.

Another provision in the EED closely linked to the EPBD is Article 7 on energy savings obligations. Almost half of the savings notified under Article 7 are reported to be generated in the buildings sector thus contributing to an accelerated rate of renovation

[206] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.156.01.0026.01.ENG

thanks to the specific measures (i.e. financing schemes and programmes) introduced by Member States to target renovation of residential and tertiary buildings.

Within the Fit for 55 package, the proposed changes to the EED related to buildings policy aim at increasing the level of the 2030 target for energy efficiency and its annual savings obligation, thus providing a higher incentive, but at the same time requiring increasing efforts from the building sector, in line with higher climate ambition. The proposed enlargement of the scope of the renovation obligation to all public bodies, and its alignment to the NZEB national standards, will contribute to an increased renovation rate. The proposed introduction of a framework for MEPS in the EPBD is coherent with that as it applies to the entire building stock. Specific national implementation measures could identify additional goals for buildings of the public sector, complementary to those in the EED.

Similarly, extending the EED obligation to only purchase buildings with high energy efficiency performance from central governments to all public bodies will contribute to the decarbonisation of public buildings. The new obligation for public bodies to assess the feasibility of using energy performance contracting for the renovation of large non-residential buildings (above 10 000 m2) will increase the role of ESCOs in promoting renovations and the energy services market in the Member States. The EED revision also aims to strengthen the role of advisory bodies and independent market intermediaries including one stop shops or similar support mechanisms to stimulate market development on the demand and supply sides, which are vital for developing a strong renovation market. New provisions on ensuring the appropriate level of competences for energy efficiency professions will have a positive impact on the quality of building renovation.

The **Renewable Energy Directive** establishes an overall policy for the production and promotion of energy from renewable sources in the EU. First adopted in 2001 and last amended in 2018, the Directive establishes a binding renewable energy target for the EU for 2030 of at least 32%. The Directive obliges Member States to require the use of minimum levels of energy from renewable sources in new buildings and in existing buildings that are subject to major renovation in so far as technically, functionally and economically feasible.

Within the Fit for 55, the proposed changes to the REDII related to buildings policy aim at increasing ambition in the 2030 target for renewables and the annual target for heating and cooling and district heating and cooling. In order to ensure an adequate contribution of buildings, which account for around 60% of all heating and cooling consumption, the revised REDII also proposes to introduce a goal for the share of renewables in the gross final energy consumption related to buildings. These goals are accompanied by an extended list of measures Member States can use to reach these targets. The list includes planned replacement schemes of fossil heating systems or fossil phase-out schemes, installation of highly efficient renewable heating and cooling systems in buildings, renewable heat planning requirements at local and regional levels and strengthened requirements on installers' training and certification.

As regards e-mobility, the proposed revision of the RED II includes provisions on the integration of EVs, in order to facilitate higher penetration of renewable electricity in the system, reduce the needs for additional storage and flexible generation assets and to alleviate potential system congestion. The proposed changes in RED II follow a system integration approach rather than being based on mobility needs only and intend to establish a framework that is applied universally, regardless of the location or type of recharging infrastructure, i.e. including in structures and areas within the scope of the EPBD as well as all other recharging points covered by AFID. The proposed provisions would require that newly installed recharging points have smart functionality and that MS ensure that the deployed recharging infrastructure is adequate (in terms of number, geographical distribution and supported technology) to enable the integration of EVs to the level needed to benefit from their flexibility and storage potential, based on regular assessments. Since recharging points in buildings form part of the overall system, this measure would affect the required number of recharging points in buildings' parking facilities, based on the number of EVs that use the premises on a regular basis.

The **Hydrogen and Gas markets Decarbonisation Package**[207] implements the EU Strategy for Energy System Integration[208] and the Hydrogen Strategy[209] and aims at contributing to the EU´s decarbonisation by facilitating the creation of a competitive market for decarbonised gaseous fuels. A review of the legislative framework to design competitive decarbonised gas markets is identified as an action in both strategies as a means to facilitate the gas sector's contribution to the overall energy system decarbonisation. The reforms should enable direct participation of renewable and low-carbon gases on the market, improve efficiency of the energy system through strengthening synergies among decarbonisation technologies and energy carriers and contribute to cost-efficient pathway toward achieving decarbonisation targets. The revision of the EPBD aims at increasing the energy renovation rate of buildings thus reducing the energy demand in the building sector, and to support the decarbonisation and electrification of heating and transport (thanks also to specific measures on e-charging for vehicles and sustainable mobility). The Hydrogen and Gas markets Decarbonisation Package will enable the availability of decarbonised energy supplied to buildings. On the other hand, the reform takes into account the expected reduction of

[207] Revision of Directive 2009/73/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC; Revision of Regulation (EC) No 715/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the natural gas transmission networks and repealing Regulation (EC) No 1775/2005

[208] https://ec.europa.eu/energy/sites/ener/files/energy_system_integration_strategy_.pdf

[209] https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf

energy demand in the building sector as a result of the initiatives in the F55 packages, as it is aligned to the future scenarios for the energy system outlined in the CTP.

2.2. Interactions with climate legislation and carbon pricing mechanisms

The **Effort Sharing** Regulation (EU) 2018/842[210] provides for Member State-specific GHG emission reduction targets for the sectors covered by this Regulation, including the building sector for the period 2021–2030. The EPBD supports the achievement by Member States of their ESR targets by incentivising energy efficiency investments in the building sector. As part of the "Fit for 55" package, it has been proposed to increase the ambition level of the Effort Sharing Regulation and Member States' national binding targets in line with the net -55% GHG reduction 2030 climate target. Member States are thus expected to increase the GHG emission reduction efforts in the sectors covered by the Effort Sharing Regulation, for instance by further reducing emissions in the buildings sector. The EPBD incentivises such emissions reductions by specifically addressing barriers to renovation.

As regards the linkages with the **Emission Trading Scheme** (Directive 2003/87/EC), within the current framework the EPBD ensures reducing emissions both outside the scope of the existing ETS and within the ETS (i.e. electricity generation) by setting cost-optimal minimum energy performance standards for new buildings and existing buildings undergoing major renovation and other supporting energy efficiency measures related to buildings[211].

As part of the revision of the EU emissions trading system (EU ETS) under the Fit for 55 legislative package, the European Commission is proposing to extend emissions trading to the building and road transport sectors. Emissions from these sectors will not be covered by the existing EU ETS but by a new, separate emissions trading system.

The revision of the EPBD is complementary both to the existing ETS in its current setting and to the introduction of a new emission trading to buildings and road transport. It contributes to an effective policy mix between market-based instruments and regulatory tools, which has been assessed in the CTP as necessary to reduce carbon emissions in buildings of around 60% by 2030. The revised EPBD would significantly contribute to the achievement of climate goals for the building sector. The EPBD will enable to overcome market failures that impede emissions abatement and that cannot be overcome by a price signal alone (see also section 2.4.3 *The complementary role of regulatory measures and carbon pricing to address the barriers to energy renovations*). The EPBD would not have any specific impact on the operation of ETS. The competent

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[210] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.156.01.0026.01.ENG

[211] The interlinkages between the ETS proposal to introduce an emissions trading to buildings and road transport and the EPBD have been already assessed in the Impact Assessment accompanying the proposal amending Directive 2003/87/EC (SWD(2021) 601 final, Sections. 6.3.5 and Annex 5 section 16.2).

authorities in the Member States and the regulated entities are in fact different, and no overlapping reporting requirement would exist. Under an upstream approach as proposed for the extension to the ETS, the new regulated entities would not be directly involved in buildings renovations.

In the current ETS framework, a carbon price signal is already applied to the energy consumed in buildings, although limited to the use of electricity. However, the increased efficiency of buildings would over time reduce emissions in the building sector, which would have to be factored in the design of the ETS, both for what concerns the strengthening of ETS applying to the power generation sector and the proposed extension to buildings and road transport. The 2030 cap of the new ETS has taken into account the complementarities, with an ambition level reflecting the combination of current legislation with a strengthened policy mix. It is based on a scenario which includes additional energy efficiency policies in the building sector which are however only approximated, and which will be complementary as regards the combined effect in achieving the 2030 55% goal. The revision of the EPBD information tools to include also a carbon metric in the energy performance certificates, renovation passports and the introduction of a deep renovation definition would enhance the carbon signal of ETS and make it more effective in reaching investors and other actors responsible for emission abatements, like manufacturers of heating appliances and other buildings technical systems.

With the introduction of emissions trading to buildings and road transport, the price incentive will contribute to the goals set in the Renovation Wave and be complementary to the instruments set in the EPBD. The carbon price signal will have an effect in ensuring a level playing field between energy carriers and in making certain low-carbon solutions for renovations and renewable heating in building more cost-effective (e.g. heat pumps). It can therefore provide an additional incentive to switching to decarbonised heating and cooling appliances in new and existing buildings, but even at high carbon price levels, analysis showed that due to low elasticities to energy prices, it is unlikely that a carbon price alone will have an effect in accelerating energy renovations. It can however reduce their pay-back time, especially for light renovations.

By introducing a carbon price and therefore increasing the energy costs, energy efficiency measures would become more cost effective and higher renovation rates and deeper renovations could be achieved.

Another important area of complementarity relates to the financial support to energy renovations and energy efficiency investments in buildings. In that context, the earmarking of financial revenues from ETS to provide social safeguards and to support investment in renovation of low-income households would facilitate the socially responsible deployment of minimum energy performance standards, thus contributing to the goals of the Renovation wave strategy.

In addition, to address any social impacts that arise from the new ETS system, the Commission has proposed to introduce the **Social Climate Fund**[212], with a twofold objective:

- To finance temporary direct income support for vulnerable households;
- To support measures and investments that reduce emissions in road transport and buildings sectors and as a result reduce costs for vulnerable households, micro-enterprises and transport users.

The Fund should provide funding to Member States to support measures and investments in increased energy efficiency of buildings, decarbonisation of heating and cooling of buildings, including the integration of energy from renewable sources, and granting improved access to zero- and low-emission mobility and transport. These measures and investments need to principally benefit vulnerable households, micro-enterprises or transport users. Strong interlinkages therefore exist between the SCF and the EPBD revision, as by supporting buildings renovations of low-income households, the fund would help making renovations more affordable for vulnerable consumers, thus supporting the goals of the EPBD revision and more specifically the roll-out of minimum energy performance standards.

The ongoing revision of the **Energy Taxation Directive** (Directive 2003/96/EC). includes as one possible option for discussion, taxation rates based on a carbon content to the sectors not covered by the ETS, on top of the energy content. This option would incentivize products with low or zero content (as hydrogen, advanced biofuels and renewable electricity) and would allow to differentiate among various fossil fuels, such as less CO2 intensive natural gas and more CO2 intensive coal. As such the EPBD revision does not have any particularly impact on the ETD but similarly to the extension of ETS, increased carbon taxation on fuels would make the technologies and solutions reducing their use more cost-effective.

The ongoing review of the F-gas Regulation (**Regulation on fluorinated greenhouse gases** (Regulation (EU) No 517/2014)**)** will further promote the use of climate friendly refrigerants in the heating and cooling systems of buildings. Notably since the improvement of the climate footprint of buildings is relying on an increased use of heat pumps that may contain strongly warming fluorinated gases, it is important that the future F-gas Regulation is ambitious in this regard to avoid locking in future F-gas emissions. Currently, all F-gases systems must be installed and maintained by a certified

[212] EUR-Lex - 52021PC0568 - EN - EUR-Lex (europa.eu).

persons and it is considered to require more elaborate skills regarding energy efficiency aspects in the certification programmes.

2.3. Interactions with transport legislation.

AFID

The Alternative Fuels Directive (AFID, Directive 2014/94/EU) and EPBD are complementary legislative instruments. Both include provisions on recharging points for electric vehicles but their scope and the obligations they put upon Member States differ. AFID sets the overall legislative framework for the standardisation and deployment of alternative fuels infrastructure, including publicly available recharging infrastructure for electric vehicles, and user information.

EPBD covers private recharging infrastructure in parkings adjacent to residential and non-residential buildings. The EPBD already requires that a certain number of parking spaces are prepared for recharging for new and renovated buildings with parkings over a certain size. The rationale for the provision in the EPBD is that the cost of ducting for recharging infrastructure is much lower if the work is made during construction or renovation, compared to adding it at a separate moment. Buildings can effectively promote e-mobility, targeting deployment of recharging infrastructure in the private domain (private buildings' car parks), and as such supplement the AFID which sets targets for the deployment of publicly accessible recharging infrastructure. Evidence shows that the majority of recharging of electric vehicles would take place in the private realm, in areas that are not publicly accessible.

AFID is being revised as part of the Fit for 55 package and policy options include setting a fleet based target at national level and a distance based target for publicly accessible recharging infrastructure (in particular along the TEN-T network). AFID establishes technical specification for recharging infrastructure as well as the general market rules for the operation of publicly accessible recharging infrastructure while fully recognising that the operation of recharging points for electric vehicles should be developed as a competitive market.

2.4. Interlinkages with other relevant legislations

The **Ecodesign Directive**[213] provides a framework for setting mandatory product-specific energy efficiency and other environmental performance requirements before products can be placed on the Union market**.** It is implemented through product-specific regulations, directly applicable in all EU countries. Currently, such requirements are in place for 30

[213] Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements.

product groups. Ecodesign is an effective tool for improving the environmental performance of products by setting mandatory minimum standards for their energy efficiency. This eliminates the least performing products from the market. Under the Ecodesign Directive, eco-design requirements have been established for technical building systems (e.g. boilers, heat pumps or light sources) and equipment used in buildings (e.g. household appliances).

The **Energy Labelling Regulation** ((EU) 2017/1369) provides a framework for establishing mandatory product-specific labelling requirements. Currently, such requirements are in place for 14 product groups. The EU energy labels provide a clear and simple indication of the energy efficiency of products at the point of purchase, allowing end-consumers to identify the better-performing products, via the well-known A-G/green-to-red scale.

Ecodesign contributes to the achievement of the energy performance levels set in the EPBD and in the national implementation measures by taking away inefficient products from the market. Energy Labelling contributes to that as well by steering consumers towards more energy-efficient products and heating and cooling appliances, while Article 7(2) of the Energy Labelling Regulation steers financing towards the most efficient appliances.

Of particular relevance for the increased synergies with EPBD are the reviews of the Ecodesign and Energy labelling requirements (including rescaling) for central/hydronic space and water heaters which are ongoing. Reviews for other types of (local or solid fuel) space heaters are also ongoing or are to be launched in 2021, with the aim of adopting rescaling measures by August 2023, so that fossil fuel appliances will be pushed down the scale which will incentivise consumers to move away from such appliance to, for example, compared to, for example, heat pumps.

The **Construction Product Regulation (**Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011) lays down harmonised rules for the marketing of construction products in the EU. The Regulation provides a common technical language to assess the performance of construction products, including on energy related aspects (e.g. energy economy and heat retention). It ensures that reliable information is available to professionals, public authorities, and consumers, so they can compare the performance of products from different manufacturers in different countries. The harmonised assessment methods of the CPR, which are available in the form of harmonised European standards, are reflecting and/or complementing requirements of other EU legislations.

The particularity of the rules on construction products results firstly from their characteristic as intermediate products. Buildings and building elements consist of several products. For example, a wall (building element) generally consists of several layers of material with various insulation properties. The energy performance of an integrated building element is more than the sum of the energy performance of the individual products involved. Proper design and installation, taking into account internal and external systemic interactions, have a big influence on the resulting performance of a building element.

Secondly, with respect to the division of powers between the EU and Member States, construction is a field of clearly identified subsidiarity. Member States have exclusive competence for building regulations (i.e. the rules on design and construction of buildings and civil works). Member States retain full control of construction design rules in their respective territories, relating in particular to public safety and security, energy efficiency and the protection of workers.

Given this background, the CPR does not lay down product requirements but contains a set of harmonised rules for assessing the performance of construction products in relation to the principal characteristics of those products. A proposal to review the CPR is currently planned for the fourth quarter of 2021. In addition to improving the implementation of the common technical language by making the standardization process more efficient, the revision will potentially aim to address the sustainability aspects of construction products. This revision should allow better information on construction products and thus facilitate the achievement of the climate objectives supported by the EPBD.

State Aid – General Block Exemption Regulations and Energy and Environmental Aid Guidelines

Lack of financing is one of the major barriers to building renovation. Public funding, where applicable compliant with well-targeted State aid rules, is essential to overcome this barrier. The ongoing revisions of the Energy and Environmental Aid Guidelines (EEAG) and the related section 7 of the General Block Exemption Regulations (GBER) aim inter alia to establish criteria ensuring that public support for building renovation qualifying as State aid, can be considered compatible with State aid rules.

Taxonomy

The taxonomy delegated act adopted on 4 June 2021 defines requirements for building renovation and individual renovation measures[214] to be considered sustainable. The deep renovation standard would complement the taxonomy requirements, establishing a gold standard for building renovation that goes beyond the taxonomy requirements.

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[214] Energy efficiency equipment such as insulation, windows and heating systems, as well as on-site renewable energy, recharging stations, building automation control systems.

3. Policy initiatives and instruments with links to the EPBD revision

Energy System Integration Strategy

The objective of the of the **EU strategy on energy system integration**[215] is to build the energy system for a climate neutral economy thanks to a more holistic planning and integration of the different end-use sectors (buildings, industry, transport) and of energy carriers (electricity, heat, liquid and gaseous fuels). Some of the main areas identified in this strategy are of particular importance for building policy.

Circular Economy

Other policy areas of relevance for buildings are those related to circular economy: a new **Circular Economy Action Plan** (CEAP) was adopted in March 2020[216]. It includes measures that will help stimulate Europe's transition towards a circular economy and encompasses the entire life cycle of products and key value chains, including construction and buildings. It provides a roadmap with actions to boost the efficient use of resources by moving to a clean, circular economy. It acknowledges that reaching climate neutrality by 2050 requires highly energy and resource efficient buildings equipped with renewable energy, considering life cycle performance and a more efficient use of resources for building renovation and construction. The Commission will draw up a 2050 whole life-cycle performance roadmap to reduce carbon emissions from buildings and is revising the Construction Products Regulation.

Climate Adaptation Strategy

The second EU strategy for adaptation to climate change, adopted in February 2021[217], considered there was a need to do more to prepare Europe's building stock to withstand the impacts of climate change. Extreme weather and long-lasting climatic changes can damage buildings and their mitigation potential e.g. solar panels or thermal insulation after hailstorms. It also recognised that buildings can contribute to large-scale adaptation, for example through local water retention that reduces the urban heat island effect with green roofs and walls. It pointed out that the Renovation Wave and the Circular Economy Action Plan identified climate resilience as a key principles. The strategy committed the Commission to explore options to better predict climate-induced stress on buildings and to integrate climate resilience considerations into the construction and renovation of buildings through various upcoming initiatives, naming specifically the revision of the EPBD.

The Zero Pollution Ambition for a toxic-free environment

[215] EUR-Lex - 52020DC0299 - EN - EUR-Lex (europa.eu)
[216] Circular economy action plan (europa.eu)
[217] EU Adaptation Strategy (europa.eu)

The Zero Pollution Action Plan[218] sets out an ambition level complementing the climate objectives. The zero pollution ambition for a toxic-free environment for 2050 goes alongside the drive for decarbonisation reducing pollution by

- phasing out polluting coal and fuel oil heating, while pollution from biomass burning remains a challenge, notably when using outdated, inefficient installations;
- promote the integration of the zero pollution ambition with clean energy and energy efficiency objectives;
- addressing the issue of healthy temperatures and levels of humidity in new buildings and in buildings undergoing major renovations, whilst tackling the issue of decontamination of toxic substances, including asbestos;
- better application of the 'polluters pays' principle.

These actions are often creating synergies and can be implemented effectively and most efficiently alongside the improvement of the energy efficiency of buildings.

European Pillar of Social Rights & European Skills Agenda

The European Pillar of Social Rights sets out 20 key principles and rights to support fair and well-functioning labour markets. These principles are the beacon towards a strong social Europe that is fair, inclusive and full of opportunity. The current EPBD framework already contribute to the creation of social and economic impact, but this effect is strengthened by the proposed provision which would provide additional stimulus to the job creation in the construction sector across its value chain. At the same time actions under the Skills agenda can help addressing skills shortages and upskilling and reskilling needs in the construction sector.

The New European Bauhaus initiative

The New European Bauhaus was launched in October 2020 with the ambition to translate the principles and objectives of the Green Deal into cultural, human-centred and tangible experiences while accelerating a sustainable greening and digitalisation of the built environment. Everyone should be able to feel, see and experience the green and digital transformation and the way it enhances our quality of life. Its objective is to articulate, in an innovative way, three key dimensions:

- sustainability (including circularity),
- aesthetics (and other dimensions of the quality of experience beyond functionality)
- inclusion (including accessibility and affordability).

[218] COM(2021) 400

The New European Bauhaus is about our daily lives, focusing on better living together in more beautiful, sustainable and inclusive places while respecting the boundaries of our planet. Delivering on the New European Bauhaus means reaching to local places, at district, neighbourhood or village level, where transformation responding to global challenges make sense for people and contribute to improve their lives.
While the New European Bauhaus has a wider focus than the built environment, a revised EPTB framework can contribute to the sustainability dimension of the initiative when integrated in a broader holistic approach.

The European Industrial Strategy

In March 2020, the Commission laid the foundations for an industrial strategy that would support the twin transition to a green and digital economy, make EU industry more competitive globally, and enhance Europe's open strategic autonomy. This was updated in May 2021 in light of the coronavirus pandemic[219]. The Industrial Strategy encompasses 14 industrial ecosystems, of which one is construction. The construction ecosystem covers contractors for building and infrastructure projects, some construction product manufacturers[220], engineering and architectural services as well as a range of other economic activities (e.g. rental and leasing of machinery and equipment, employment agencies). Starting in 2021 the Commission will co-create jointly with industry and stakeholders, transition pathways to identify the actions needed to achieve the twin transitions, giving a better understanding of the scale, benefits and conditions required.

LEVEL(s)[221] is a common European approach to assess and report on the sustainability of buildings. It is an important tool to help architects, builders and public authorities designed to improve the sustainability of buildings throughout their lifecycle, helping professionals deliver better buildings – while also speeding Europe's transition towards a more circular economic model. The LEVEL(s) framework covers energy, material and water use, quality and value of buildings, health, comfort, resilience to climate change and life-cycle cost. Level(s) could form a basis for renovations as well as new constructions to assess and report their sustainability in a consistent and coherent manner, using established indicators.

Roadmap for the reduction of Whole Life Carbon of buildings

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[219] https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-industrial-strategy_en
[220] Some categories of products which are essential to construction, such as cement, glass, ceramics and tiles, plastic pipes are covered under the Energy Intensive Industries ecosystem.

The Renovation wave strategy includes an action setting out how the European Commission will develop, by 2023, a roadmap leading up to 2050, for reducing whole life-cycle carbon emissions in buildings.

This roadmap shall be able to serve as a basis and guidance to future policy and market developments for a long period of time and at different geographical levels - EU as well as national. It shall be directly linked to and consistent with other relevant existing EU strategies and policies and support the achievement of the overall climate objectives. It shall provide a vision and in this way set out the direction of travel for the sector and public authorities. In this way, it will support future work linked to the EPBD, in setting targets as well as minimum values, for new built and renovation.

The EU Framework Programmes for Research and Innovation

The Energy Efficient Buildings (EeB) Horizon 2020 Public Private Partnership has developed technical solutions and innovative technologies that are relevant for the EPBD[222]. Following the EeB, Horizon Europe will support a Public-Private Partnership on People-centric Sustainable Built Environment (Built4People) that will deliver innovation to the buildings and construction industry. Horizon Europe supports also a dedicated Mission on Climate-Neutral and Smart Cities that aims to showcase 100 cities in their systemic transformation towards climate neutrality by 2030 together and for the citizens. In addition, the Horizon Europe Clean Energy Transition Partnership, co-funded with Member States, will contribute to developing climate-neutral solutions for heating and cooling systems in buildings.

The Technical Support Instrument

The Technical Support Instrument supports Member States in designing, developing and implementing reforms. The support is provided upon request and covers a wide range of policy areas, including building renovation, also in the context of the Recovery and Resilience Facility. In particular, such support of reforms and capacity building comprises the thematic areas highlighted in the Renovation Wave communication, the development and implementation of the national long-term renovation strategies, as well as the improvement of building renovation financing conditions and the implementation of available funding instruments.

[222] EeB searching engine: http://e2b.ectp.org/project-database-list/