EUROPEAN
COMMISSION

Brussels, 15.12.2021
SWD(2021) 453 final

PART 1/4

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}

Table of contents

Glossary

Term or acronym	*Meaning or definition*
AFID	Alternative Fuels Infrastructure Directive
AFIR	Alternative Fuels Infrastructure Regulation
BACS	Building Automation and Control System
BSO	Building Stock Observatory
BRP	Building renovation passport
CPR	Construction Products Regulation
CTP	Climate Target Plan
DHW	Domestic hot water
EEAG	Energy and Environmental State Aid Guidelines
EED	Energy Efficiency Directive
EGD	European Green Deal
EPBD	Energy Performance of Building Directive
EPC	Energy performance certificate
ESR	Effort Sharing Regulation
ETD	Energy Taxation Directive
ETS	Emissions Trading System
EU SILC	European Union Statistics on Income and Living Conditions
EV	Electric vehicle
GBER	General Block Exemption Regulation
GHG	Greenhouse gases
HVAC	Heating, ventilation and air conditioning systems
LMFH	Large multi-family house
LTRS	Long-term renovation strategies
MEPS	Minimum energy performance standards
MSs	EU Member States
Mtoe	Million tonnes of oil equivalent
NECP	National Energy and Climate Plans
NZEB	Nearly zero-energy building
RED	Renewable Energy Directive
RRF	Recovery and Resilience Facility
RRPs	National Recovery and Resilience Plans

SCF	Social Climate Fund
SFH	Single family house
SRI	Smart readiness indicator
ZEB	Zero emission building

1. INTRODUCTION: POLITICAL AND LEGAL CONTEXT

1.1 From the European Green Deal to the Fit for 55 package

1.1.1 Introduction

In December 2019, the Commission presented the European Green Deal[1]. The Green Deal sets out a strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use. The European Climate Law[2], as agreed with the co-legislators, makes the EU's climate neutrality target legally binding, and raises the 2030 ambition by setting a target of at least 55% net emission reductions by 2030 compared to 1990.

The building sector has a crucial role in achieving this goal. Buildings are the largest energy consumer in the EU, where they are responsible for approximately 40% of energy use and 36% of energy-related greenhouse gas emissions[3]. The renovation of buildings has also a significant relevant economic dimension, as the construction industry ecosystem (buildings and infrastructure) generates about 9.6% of EU value added and employs almost 25 million people in 5.3 million firms[4].

Based on the European Green Deal strategy and a comprehensive impact assessment, the Commission's Communication of September 2020 on Stepping up Europe's 2030 climate ambition (the '2030 Climate Target Plan')[5] proposed to raise the EU's ambition and put forward a comprehensive plan to increase the EU's binding target for 2030 towards at least a 55% net emission reduction, to be met in a responsible way.

Raising the 2030 ambition now helps give certainty to policymakers and investors, so that decisions made in the coming years do not lock in emission levels inconsistent with the EU's objective to be climate-neutral by 2050. The 2030 target is in line with the Paris Agreement objective to keep the global temperature increase to well below 2°C and pursue efforts to keep it to 1.5°C. The Climate Target Plan (CTP) 2030 identifies buildings as a major area where common EU decarbonisation efforts can be strongly increased. The analysis underpinning the CTP concluded that a mix of instruments from climate, energy and transport policies is needed. Moreover, the EPBD's regulatory tools need to be strengthened to address the non-economic barriers that leave the renovation rate at a level which is too low and incompatible with achieving the enhanced climate

[1] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
[2] Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law') (OJ L 243, 9.7.2021, p. 1).
3 Including direct emissions from buildings and indirect emissions stemming from electricity and heat consumed in buildings.
[4] SWD(2021) 351 final.
[5] *Stepping up Europe's 2030 climate ambition Communication* COM (2020) 562 final.

and energy goals. Building renovation and improvement of their energy performance reduces energy needs and energy bills: better insulated buildings are therefore a safeguard against the volatility of energy prices and their increase, especially for more vulnerable consumers, and contribute to the goal of security of supply. In addition, the EPBD is expected to contribute to the reduction of emissions in the transport sector, specifically by enabling the charging of e-vehicles in private buildings and supporting sustainable mobility.

The ‘Fit for 55 package’ was therefore conceived by the Commission as a comprehensive policy package to enable action to meet this increased ambition; the revision of the Energy Performance of Buildings Directive (EPBD) is part of the intended policy tools. The revision of the EPBD was in fact included in the 2021 Commission work programme listing all legislative acts to be reviewed under the heading ‘Fit for 55’.

The analysis from the CTP was repeated in preparation of the ‘Fit for 55 package’ and the above findings and policy conclusions of the CTP were confirmed. Without a revision of the EPBD driving higher energy renovations, the net 55% greenhouse gas emissions reduction target for 2030 will not be achieved. In particular, without the policy drivers from a revised and strengthened EPBD, we will be facing a gap representing 49% of the efforts to decarbonise the building sector. This impact assessment fulfils the role of developing and assessing policy options to strengthen existing measures and tools to make them ‘Fit for 55’, and align them with climate neutrality in the long term, based on the policy conclusions of the Climate Target Plan and focusing on the areas identified in the Renovation Wave strategy.

This initiative is part of a policy mix with strong interlinkages among instruments, similar to the assessment made when preparing legislative proposals for the revised Energy Efficiency Directive (EED), Emissions Trading System (ETS), the recast Renewable Energy Directive (RED II), Effort Sharing Regulation (ESR) and Alternative Fuels Infrastructure Regulation (AFIR). As such, the initiative takes into account the interplay with the other proposals, in order to maximise its complementary role.

Significantly scaling up efforts in reducing emissions and increasing energy performance and renewable deployment in the building sector is imperative to achieve the EU decarbonisation goal. Nevertheless, the efforts to be made come with substantial challenges, which accompany the green transition. Lack of skilled workforce in the construction sector across its value chain, potential materials shortages and product supply-chain bottlenecks can hamper the upscaling of renovations across Europe and call for a wider policy response. In addition, with new buildings being constructed and existing buildings renovated, greenhouse gases are emitted during the extraction and manufacturing of construction materials, and during transport and construction. To address those challenges, it is essential that this initiative is accompanied by appropriate measures supporting the green transition. The Renovation Wave strategy has identified a series of measures which are being implemented, and buildings and construction activities also feature in the other strategies following the Green Deal, including the Pact for Skills, the Industrial Ecosystem Strategy, the Zero Pollution Action Plan, the Circular Economy Action Plan, the Biodiversity Strategy and the Climate Adaptation Strategy.

Buildings also have a strong societal dimension and their use reflects behavioural trends and dynamics in society. The COVID-19 pandemic has had an impact on building use patterns, such as working more from home, which are likely to last beyond the recovery period and require adaptations of the building stock, both for residential and non-residential buildings. The revision of the EPBD is timely as it can contribute to ensuring improved building performance in this dynamic phase and is thus an important measure alongside the Recovery and Resilience Facility.

1.1.2 Alignment with the 2030 Climate Target Plan policy conclusions

The Climate Target Plan (CTP) 2030 states that EU buildings by 2030 should reduce their overall greenhouse gas emissions by around 60%[6], their final energy consumption by 14% and energy consumption for heating and cooling by 18%[7] in comparison to 2015. The analysis in the CTP also found that greenhouse gas emissions can only be lowered cost-effectively to a level compatible with achieving the goal of -55% by duplicating the floor area renovated every year to improve its energy performance, decarbonising heating and considerably increasing the energy savings achieved through renovations.

The impact assessment of the 2030 Climate Target Plan provided an indication of what effects a combined policy mix could have on reaching the new climate target and subsequent climate neutrality by 2050. However, the impact assessment required further clarifications and additional analysis to reach the level of details needed to support the individual sectoral legislative proposals. As regards the EPBD revision, which focuses on sectoral building policy, the MIX scenario in the CTP impact assessment representing the most cost-effective mix of policies between regulatory and carbon pricing mechanisms, made revising the EPBD the driver of increased energy renovation through standards and strengthened regulations. Without the policy driver of the EPBD revision assumed in the MIX scenario, the renovations rate will not increase sufficiently. This would result in the target for reducing GHG emissions being missed by around 49% and the 2030 target for reducing final energy consumption attributed to the buildings sector in the Climate Target Plan being missed by 40% (see Section 6.2).

The CTP analysis also confirmed the finding from other assessments that energy efficiency is an essential component of action towards increased climate ambition across sectors including in buildings, and also via systematic application of the 'energy

[6] In this impact assessment, in line with the approach of the Climate Target Plan for the building sector, when referring to GHG emissions, reference is made to operational emissions from energy use. When emissions refer to the embodied carbon content of buildings, this is clearly indicated.
[7] SWD(2020) 176 final.

efficiency first' principle. Reducing first the energy needs of buildings is a more sustainable and cost-effective way to reduce emissions than investing in additional clean energy generation to compensate buildings' low energy performance[8]. Even in an increasingly and progressively decarbonised energy sector, improving the energy performance of existing buildings is necessary to avoid unnecessary investments in energy infrastructure and to improve the living conditions of the EU public[9]. For buildings, a combination of the 'energy efficiency first' principle and expansion of renewable energy is needed because renewables are not available indefinitely and can only contribute a limited amount of the greenhouse gas emission reductions in the buildings sector[10]. Combining the green and digital transitions, smart buildings can enable efficient production and use of renewables at building, district and city level, help decarbonise the transport sector and promote the circular economy.

The CTP identified specific measures to ensure the appropriate pace at which to improve the building stock. These include the potential introduction of mandatory standards for the worst-performing buildings and the gradual tightening of the minimum energy performance requirements[11]. Additionally the CTP flagged up long-term renovation strategies within the context of the EPBD as a key policy vehicle. Their aim would be to introduce additional measures to remove barriers to building renovation and strengthen pull factors for faster and deeper energy renovation.

1.1.3 Coherence within the 'Fit for 55' package and the role of the EPBD revision

To follow the pathway proposed in the European Climate Law and deliver this increased level of ambition for 2030, the Commission has reviewed the climate and energy legislation currently in place. These are expected to only reduce greenhouse gas emissions by 40% by 2030 and by 60% by 2050. The 'Fit for 55' legislative package, as announced in the 2030 Climate Target Plan, is the most comprehensive building block in the efforts to implement the ambitious new 2030 climate target, and all economic sectors and policies will need to make their contribution. The majority of the proposals in the 'Fit for 55' legislative package were adopted by the Commission on 14 July 2021, while the revision of the EPBD is scheduled for a slightly later date to take into account the analysis and steer coming from the Renovation Wave strategy adopted in October 2020.

---

[8] Net Zero by 2050 Scenario - Data product - IEA

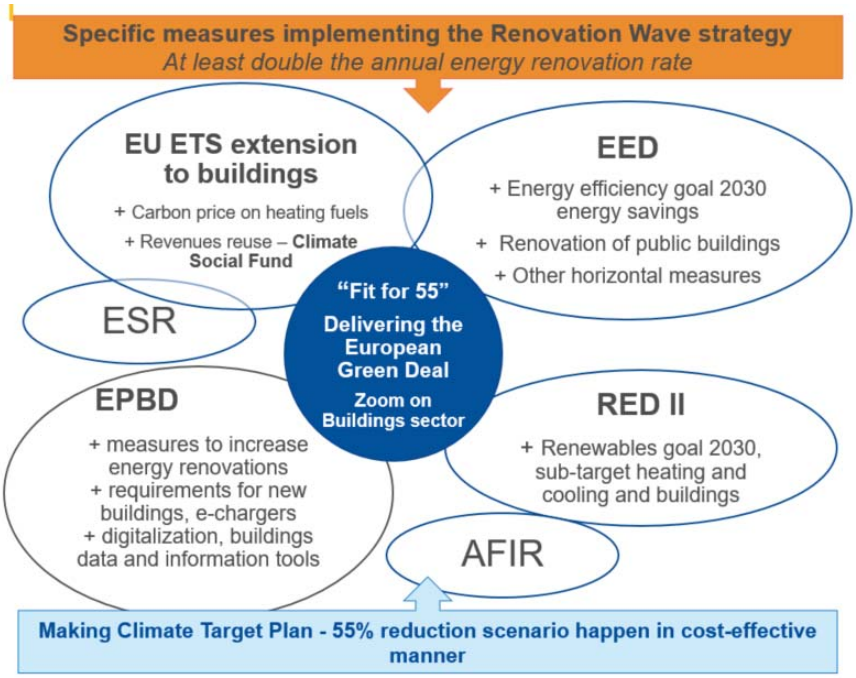
[9] Building codes with specific regulation on thermal insulation of the building envelope started appearing after the 1970s in Europe. This means that a large share of today's EU building stock was built without any energy performance requirement: one third (35%) of the EU building stock is over 50 years old, while more than 40% of the building stock was built before 1960. Almost 75% of it is energy inefficient according to current building standards. Source: JRC report *Achieving the cost-effective energy transformation of Europe's buildings*.

[10] ENEFIRST, 2021 http://enefirst.eu

[11] See also Annex J: 2030 Climate Target Plan Policy Conclusions.

The ‘Fit for 55’ legislative package is a set of a comprehensive and interconnected proposals which will enable an acceleration of greenhouse gas emission reductions in the next decade. They combine the following initiatives: (i) application of emissions trading to new sectors and a tightening of the existing EU Emissions Trading System; (ii) increased use of renewable energy; (iii) greater energy efficiency; (iv) faster roll-out of low emission transport modes and the infrastructure and fuels to support them; (v) alignment of taxation policies with the European Green Deal objectives; (vi) measures to prevent carbon leakage; and (vii) tools to preserve and grow our natural carbon sinks. The proposals were accompanied by a ‘*Fit for 55’: delivering the EU’s 2030 Climate Target on the way to climate neutrality*[12] Communication, which explain the logic of the policy mix chosen to deliver on the target of -55%, which is a careful balance between pricing, targets, standards and support measures in a whole-of-the-economy approach. The Communication clearly highlights the revision of the EPBD as parts of the efforts to deliver the EU’s 2030 Climate Target.

Figure 1.1: EPBD Interactions with other key legislation affecting the energy performance of buildings



The proposals adopted in July 2021 include measures targeting the buildings sector; the EPBD revision is consistent with and ensures complementarity with these. Without a strengthening of the EPBD, the -55% goal will not be achieved, making it necessary to strengthen other measures or to move to a higher carbon price.

[12] COM(2021) 550 final.

The above figure illustrates the main measures addressing buildings in the 'Fit for 55' package. See Chapter 7 for more details on these and the interactions with the revision of the EPBD.

1.1.4 The scope of greenhouse gas emissions covered in the EPBD revision and coherence with other initiatives addressing whole-life cycle carbon emissions

In line with the CTP, the scope of this initiative is to improve energy performance and reduce GHG emissions during the use phase of buildings. The emissions covered are direct emissions from energy use in buildings[13] (e.g. from a gas boiler in the building used for space heating) and indirect emissions from the use of electricity and heating and cooling supplied to the building (e.g. through electric heating or a district heating network)[14].

For clarity, all GHG emissions mentioned in this document refer to operational GHG emissions, unless otherwise stated.

In addition to emissions during the use phase, there are emissions that occur during other parts of the building life cycle. These include 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. deconstruction or demolition) process and transport and reuse, recycling or disposal of waste[15,16,17]. The revision of the EPBD contributes to the policy efforts at EU level to address these emissions with a specific measure, which is the mandatory calculation and display of life-cycle emissions for new buildings (see Annex H, Section 3). Addressing the whole-life carbon impact issue was widely underlined by stakeholders during the open consultation, who suggested including measures in the EPBD to account for carbon emissions over the entire life cycle of buildings (68%).

The measure proposed in the EPBD revision can complement other EU policies aimed at reducing lifecycle emissions in buildings. In particular, there will be no overlap between the measure in the EPBD revision and the Construction Product Regulation (CPR). The CPR provides a common technical language to assess the performance of construction products. The CPR 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.

---

[13] The energy use regulated through the EPBD is heating, cooling, ventilation, domestic hot water, built-in lighting and other technical building systems. See EPBD Annex 1.
[14] This corresponds to the emissions in the residential and service sector and part of the emissions in the power sector and heating and cooling sector in the CTP.
[15] Röck, M. et al. (2020) *Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation*.
[16] 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.
[17] https://www.bpie.eu/wp-content/uploads/2021/05/BPIE_WLC_Summary-report_final.pdf

The calculation of life-cycle emissions on building level in one of the proposed measures under the EPBD[18] will be made using the European Level(s) framework or equivalent (as also referenced in the EU Sustainable Finance Taxonomy). In the Level(s) framework, the life cycle analysis of buildings uses product data calculated on the basis of existing assessment methods under European standards or under the CPR when available.

The EPBD is also in line with initiatives such as the forthcoming Communication on restoring sustainable carbon cycles[19] and the proposal for a regulatory framework for carbon removal certification[20] and the findings of the study on Circular Economy Principles for Buildings' Design[21]. The study analysed case studies of circular economy policies in construction at national and regional level across the EU and other OECD countries, and suggested policy options at EU level. It found possible opportunities in the Construction Products Regulation, the Energy Performance of Buildings Directive, in green public procurement, and in guidance for local and regional planning authorities. The proposed measure in the EPBD complements well the provisions in these policies.

1.2 The revision of the EPBD in the Renovation Wave strategy

In line with the Green Deal, on 14 October 2020 the Commission adopted the strategic Communication *A Renovation Wave for Europe – greening our buildings, creating jobs, improving lives*. 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 contains an action plan with concrete regulatory, financing and enabling measures for the years to come and pursues the aim to at least double the annual energy renovation rate of buildings by 2030 and to foster deep renovations. It is expected that mobilising forces at all levels towards the objectives of the Renovation Wave will result in at least 35 million building units renovated by 2030.

The Renovation Wave 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 the worst-performing buildings, on renovating public buildings and social infrastructure and on decarbonising heating and cooling. It also flags that research must spur innovation in the construction industry ecosystem for this transformation, in line with the twin green and digital transitions. Energy renovation of the existing building stock 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,

[18] See Chapter 5.2, in particular the description of ZEBs on life-cycle reporting. See also Annex H.
[19] Planned for adoption in December 2021.
[20] Planned for late 2022.
[21] *Study on circular economy principles for buildings' design*, Publications Office of the EU (europa.eu).

standardised smart charging points for e-mobility and bike parking. The construction industry ecosystem is expected to play a key role in the implementation of the Renovation Wave and in transforming buildings in line with climate objectives, in particular with integrated design and execution, enhanced quality controls and compliance checks, high resource efficiency in line with circularity principles, and uptake of skills in construction in line with the twin green and digital transitions.

The 23 implementation action points identified in the strategy include regulatory measures, with a strengthening of the EU legislative framework of the Energy Efficiency Directive (EED), the Renewable Energies Directive (RED), the Ecodesign Directive and the EPBD[22]. They also include the possible extension of emissions trading to the buildings and the road transport sectors, which would introduce a carbon price for fossil fuel use in those sectors. The strategy was also accompanied by the establishment of the New European Bauhaus[23]. The extensive preparatory work and stakeholder consultation on the key aspects to be addressed in the Renovation Wave strategy[24] identified key measures and instruments, either to be strengthened or newly designed in the EPBD revision. These include the introduction of mandatory minimum energy performance standards for all types of buildings, the revision of the energy performance certificates framework, and building renovation passports. The current EPBD revision addresses 3 of the 23 key Commission actions to implement the Renovation Wave and some of its main regulatory measures.

1.3 The Energy Performance of Buildings Directive

1.3.1 The current EPBD framework

Over the last years, due to a well-established regulatory framework for the energy performance of buildings and higher standards for equipment and appliances, the EU building stock has become more efficient. This is particularly the case for new buildings. The market diffusion and lowering of price of renewables has increased their uptake by buildings owners.

The EPBD Directive (2010/31) is the main legislative instrument for promoting energy performance improvements in buildings in the EU. The EPBD is the cornerstone of EU legislation on energy efficiency for buildings. It was first adopted in 2002 by means of Directive 2002/91/EC. This Directive was then replaced and also substantially reinforced

[22] See Annex K for an overview of the EPBD revision in the context of the Renovation Wave action plan.
[23] 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.
[24] Stakeholder consultation on the Renovation Wave initiative, https://ec.europa.eu/energy/sites/ener/files/stakeholder_consultation_on_the_renovation_wave_initiative.pdf

in 2010 by Directive 2010/31/EU. That was a recast Directive, which was amended in 2018 by Directive (EU) 2018/844 as part of the Clean Energy Package for All Europeans. The objective was to modernise the building stock in the light of the latest technological developments by promoting an optional smart readiness indicator scheme, facilitating the deployment of infrastructure for electro-mobility in buildings, and the better integration of automation systems and renewable solutions[25]. The amending Directive entered into force in July 2018 and Member States had to transpose it into national law by 10 March 2020.

The EPBD (2010/31/EU), as revised by Directive (EU) 2018/844), aims to transform the EU building stock into a highly energy efficient and decarbonised building stock by 2050, moving towards nearly zero-energy building standards. The Directive works through two complementary mechanisms: (i) minimum performance requirements for new and existing buildings (raising the depth of any upgrades and the standards for new-builds); and (ii) information for the public and companies through energy performance certificates for buildings to enable them to choose the efficiency level that is right for them. The Directive sets specific energy performance requirements for new and renovated buildings and on technical building systems (which include renewable energy and heating and cooling systems). The cost-optimal methodology helps Member States set their ambition levels right and keep them under review. Taken together, these mechanisms contribute to setting the right energy performance standards for different buildings, and facilitate information on more energy-efficient housing.

The most important measures in the current EPBD are:

- long-term renovation strategies aiming to decarbonise national building stocks by 2050, with indicative milestones for 2030, 2040 and 2050;
- cost-optimal minimum energy performance requirements for new buildings, for existing buildings undergoing major renovation, and for the replacement or renovation of building elements like heating and cooling systems, roofs and walls[26];

[25] In the area of building automation and control systems, the EPBD introduced in 2018 a definition for such systems and a requirement for all non-residential buildings over 290 kW to have Building Automation and Control Systems (BACS) installed. In addition, there were provisions to support the installation of devices to enhance monitoring and control functionalities in residential buildings. New provisions were introduced to Article 8 of the EPBD with regard to technical building systems, in particular concerning the installation of thermal regulating devices in each room and the recording of information related to the energy performance of systems upon completion of works.

[26] Article 4(1) (EPBD) requires Member States to take the necessary measures to ensure that minimum energy performance requirements for buildings or building units are set with a view to achieving cost-optimal levels. Article 5 of the EPBD requires Member States to calculate cost-optimal levels of minimum energy performance requirements for buildings and building elements using a comparative methodology framework to be established by the Commission.

- requiring, since 31 December 2020, all new buildings to be nearly zero-energy buildings (NZEBs); new public buildings already had to be NZEBs since 31 December 2018;
- energy performance certificates (EPCs) to be issued when a building is sold or rented and requiring their rating to be visible in the advertising media;
- inspection schemes for heating and air conditioning systems;
- electro-mobility is supported by minimum requirements for charging points and ducting infrastructure car parks over a certain size;
- an optional European scheme for rating the 'smart readiness' of buildings (SRI);
- the promotion of smart technologies, including through requirements on the installation of building automation and control systems (BACS), and on devices that regulate temperature at room level;
- addressing the health and well-being of building users, for instance by considering the air quality and ventilation that Member states should take into account when defining energy needs.

The EPBD requires Member States to establish a long-term renovation strategy to support the renovation of their national building stock, so that by 2050 the building stock is highly energy-efficient and decarbonised. The long-term renovation strategies must include: (i) an overview of the national building stock policies and actions to stimulate cost-effective deep renovation of buildings, (ii) policies and actions to target the worst-performing buildings, split-incentive dilemmas, market failures, energy poverty and public buildings; and (iii) an overview of national initiatives to promote smart technologies and skills and education in the construction and energy efficiency sectors. The strategies must also include a roadmap with measures and measurable progress indicators indicative milestones for 2030, 2040 and 2050, an estimate of the expected energy savings and wider benefits, and the contribution of the renovation of buildings to the EU's energy efficiency target. The 2020 long-term renovation strategies[27] (LTRS) adopted by Member States have been assessed by the Commission[28]. These strategies fed into the preparation and assessment of national resilience and recovery plans and this impact assessment.

In addition, the Directive is accompanied by secondary legislation. The Commission published in October 2020 two regulations (an implementing act[29] and a delegated act) on

[27] https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/long-term-renovation-strategies_en

[28] Commission staff working document on Preliminary analysis of the long-term renovation strategies of 13 Member States, SWD(2021) 69 final. An update of the assessment covering the remaining LTRS will be published in December 2021.

[29] Implementing Regulation detailing the technical modalities for the effective implementation of an optional common Union scheme for rating the smart readiness of buildings, C(2020) 6929 final, https://ec.europa.eu/energy/sites/ener/files/smart_readiness_buildings_implementing_act_c2020_6929.pdf

establishing an optional common EU scheme for rating the smart readiness (SRI) of buildings, accompanied by associated annexes (based on the empowerment given by Article 8 EPBD, introduced by Directive (EU) 2018/844). The delegated act on cost-optimality (Delegated Regulation No 244/2012)[30] and the accompanying guidelines[31] support Member States in calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements, using the comparative methodology framework established by the Commission.

The Commission has also published a series of recommendations on building renovation ((EU)2019/786) and building modernisation ((EU)2019/1019) aspects. These are linked to the new rules introduced in 2018 in the EPBD.

1.3.2 The progress achieved

While the evaluation of the EPBD in 2016 revealed some weaknesses, notably inefficiencies in national implementation, the EPBD is overall a successful regulatory instrument that has led to significant energy savings in the buildings sector (about 49 Mtoe of energy savings from 2007 to 2013[32]) and has grown over time in ambition and scope. It has spurred significant changes in the national buildings codes and standards for minimum energy performance requirements, in relation to major renovations of existing buildings and in relation to new buildings, and has introduced the energy performance certificate, an information tool which is present and used in each country and by the financial sector. The nearly zero-energy building requirements for new buildings provided the necessary longer-term predictability for investors, offered stakeholders a common vision for the sector, and mobilised industry to deliver business models and technologies.

One of the main reasons why the current EPBD does not yet deliver on the required push for building renovation is that it does not contain any obligations directly triggering building renovation.

[30] Commission Delegated Regulation (EU) No 244/2012 of January 2012 supplementing Directive 2010/31/EU of the European Parliament and of the Council establishing a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements.
[31] Guidelines accompanying Commission Delegated Regulation (EU) No 244/2012 of 16 January 2012 supplementing Directive 2010/31/EU.
[32] This is equivalent to the gross inland consumption of both Austria (34.7 Mtoe) and Ireland (14.96 Mtoe) together in 2019 (49.66 Mtoe). Over 2007-2013, direct GHG emissions were reduced by 63 Mt CO_2 (i.e. 8% of the 1990 emissions of the household and service sector).

2. PROBLEM DEFINITION

2.1 Introduction

This section provides first an overview of the barriers preventing higher levels of renovations, which are complex and multi-layered. Not all are addressed by the revision of the Energy Performance of Buildings Directive (EPBD). Annex N provides key information related to the characteristics of the building stock and the ownership structure of buildings, which are relevant to understand the origin of the problems addressed. Such an overview helps identify key drivers of the problems addressed in this initiative and also assess the interplay of the EPBD revision with other measures of the 'Fit for 55' package, in particular carbon pricing. This section finishes by outlining the two key problems addressed by the EPBD revision and their drivers, concluding with their expected evolution.

2.2 Barriers to energy renovations

The strategic Communication on the Renovation Wave addressed the need to significantly increase energy renovations in the EU by setting the objective to at least double the annual energy renovation rate of residential and non-residential buildings by 2030.

While preparing both the Renovation Wave Communication and the impact assessment, a number of stakeholder consultations, in-depth literature reviews and targeted studies were undertaken to identify the different sets of barriers to energy efficiency renovation in buildings in EU countries. Some of these barriers are more or less relevant depending on the Member States, and sometimes on regions within them. However, albeit with a different weight across Europe, all of these barriers taken together account for the insufficient annual renovation rates in the EU and the existing gap towards the 2030 decarbonisation target for the building sector.

The barriers to energy renovations can be divided in six main categories:

(1) Economic and financial barriers associated with building renovations – from the high upfront costs and affordability of renovation, access to finance, the issue of split incentives (which are also and organisational barrier), to the relevant opportunity and transaction costs and high discount rates;

(2) Behavioural barriers related to consumer support for the uptake of energy renovations – from the lack of knowledge and conflicting information on the energy performance of buildings and multiple benefits of energy renovations, to a general lack of acceptance of the need to step up decarbonisation efforts, including in buildings, the inertia (bounded rationality), the perceived hassle of renovations, and the aversion to indebtedness and financial risk;

(3) Information barriers associated with the lack of accessible, transparent and comparable information across the board and in EU countries on the decarbonisation trajectory for buildings, lack of comparable and standardised information tools on the energy performance of buildings across the EU, as well as the lack of information on available funding for energy renovation investments and on the potential lower credit risk associated with energy efficiency investments[33];

(4) Administrative barriers related to both insufficient technical expertise and capacities among local and regional authorities to support building renovation programmes, lengthy administrative processes and permit procedures;

(5) Technical barriers related to the possible shortage of skilled workforce for energy renovation, lack of standardised practices and industrialised solutions in the building renovation market, as well as the lack of skills and accessible advisory and quality assurance support for non-professional building owners;

(6) Organisational barriers associated with the complexity of building ownership and use, where co-ownership and collective decisions are often the norm, and where the commercial lease of buildings and building units add to the complexity and split incentives.

On top of these six categories of stable barriers, some temporary and periodic barriers might arise that affect energy renovations across EU countries. These are often of a macro-economic nature and related to market cycles, market interventions and market adjustments. In the last 2 years, a number of consequences that stem from the COVID-19 pandemic have affected the market of energy renovations. The interruption of global shipping routes has had a cascade effect on the availability of construction materials. At the same time, the high number of public subsidies in EU countries for energy renovation released on the market, in particular by the Recovery and Resilience Facility, has generated a temporary shortage of skilled workforce for energy renovations and made renovations more expensive. While the demand for energy renovations in buildings is expected to grow in the next year, these initial shocks are expected to recede and the market is expected to adjust.

The following table outlines the barriers to building renovations, with Annex E (Intervention logic and common barriers to building renovations) explaining them in more detail.

[33] Based on initial evidence from the EEFIG SR8 working group. A special report on this and other assets and activities related to environmental objectives, including energy efficiency and building renovations investments, is expected from the European Banking Authority in 2023 https://ec.europa.eu/eefig/eefig-working-group-risk-assessment_en

Table 2.1: Barriers to building renovations

Type of barrier	Barrier
Financial barriers	Upfront costs and affordability of energy renovations
	Weak economic signal
	Split incentives
	Lack of access to public and private financial support for affordable renovations
	Limited public funds, public financial support not sufficiently targeted towards deep renovations
	Lack of clear property value differential
	Transaction costs, high discount rates
Behavioural/consumer barriers	Lack of knowledge, conflicting or lack of information on energy performance of buildings and multiple benefits of energy renovations
	Time and hassle factor, inertia and bounded rationality
	Perceived risk, attachment to incumbent technologies
	Lack of acceptance of need to step up decarbonisation efforts, including in buildings
	Aversion to financial risk and indebtedness for energy efficiency investments
Information barriers	Lack of well-communicated decarbonisation trajectory
	Lack of standardised information tools on energy performance
	Lack of information on available funding opportunities (public and private) for energy renovations on buildings, and on the potential lower credit risks of energy efficiency investments
Administrative barriers	Regulatory & planning (e.g. limitation in façade intervention, approval process for renewable installation and renovation permits)
	Lack of technical expertise and capacities in regional and local administration for energy efficiency renovation programmes
	Burdensome administrative processes (multiple permit procedures, no single entry point)
Technical barriers	Lack of skilled workforce for energy efficiency renovations, lack of low-carbon renovation skills
	Lack of standardised practices and industrialised fast-track solutions for energy renovations in buildings
	Lack of quality assurance for complex renovation
Organisational/building complexity barriers	Collective decision problems for co-owned properties
	Commercial lease barriers

The barriers identified in the above table are largely common across EU countries, although their weight in the overall decision-making process to embark on energy renovations can be different depending on specific national circumstances. Two of the most common barriers are the issue of split incentives and access to finance to bridge the upfront cost and affordability of energy renovations. In their long-term renovation strategies[34], 16 Member States clearly underline the issue of split incentives as one of the most relevant barriers to energy renovations. Although the issue of split incentives is common across Europe, some of its most striking features are affected by national differences[35]. While the issue of split-incentive is included into 'economic and financial barriers' as it relates to the mismatch of economic incentives, it cannot be alleviated by economic incentives alone, and it combines with organisational barriers. As outlined in Annex N, the owner-tenant ratio presents some differences across Member States, with the number of people living in rented accommodation much higher in Germany (49%), Austria (45%), Denmark (39%), and France (36%), compared to an EU average of 30%. The owner-tenant ratio has a direct impact on the relevance of the split incentive issues in designing policy for energy renovations of national building stock. In southern Europe, south-east and north-east Europe, people own rather than rent housing, with countries in south-east Europe having a high ownership ratio. Similarly, the possibility to increase rents following energy renovations is regulated differently across EU countries, with northern and western European countries having more regulatory social safeguards. The difficulties in finding appropriate measures that properly address the issue of split incentives was also highlighted, especially by non-governmental organisations (NGOs), in the consultation on the inception impact assessment. While tenant associations largely favoured the need for measures that introduce obligations for building owners, the renovation hassle and risks of 'renovictions' was also mentioned as a possible negative consequence of renovations.

Access to finance to bridge the upfront costs of energy renovations is also a very common barrier across all EU countries. This was underlined by multiple stakeholders during the targeted EPBD revision and Renovation Wave consultations (Annex B). Moreover, private financing products for energy efficiency renovations are not sufficiently developed and marketed across EU countries, which reduces access to favourable financial offers. Moreover, insufficient cost-effective use of EU and national financing to leverage additional private investments and the lack of appropriate information tools to better target financing towards deep renovation and the worst

[34] Long-term renovation strategies 2020, https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/long-term-renovation-strategies_en#national-long-term-renovation-strategies-2020
[35] Castellazzi (2017); Overcoming the split incentive barrier in the building sector.

performing buildings is often underlined across the board as part of public resources spending[36].

Across the EU, technical barriers experience similar trends to administrative and information barriers. Overall, they are more relevant in Member States where the uptake of energy renovations appears to be less strong. In addition, a number of Member States identify a close link between the administrative burden barriers of renovation, the behavioural barriers related to the hassle of renovations, and organisational barriers linked to building ownership status and the collective decision-making of co-owned immovable goods.

2.3 What are the key problems?

While the previous sections focus on the overall barriers to renovating buildings, this section focuses on the barriers that can be addressed by the revision of the EPBD.

*2.3.1 **The first key problem:** The EPBD framework is insufficient to achieve the 2030 climate objectives. No specific measure is in place to address non-economic barriers that limit the energy renovation of buildings.*

As previously indicated, the main aspect currently hampering the progressive decarbonisation of the building stock in the EU is the low renovation rates across EU countries. The EPBD framework is incapable of overcoming this problem because it does not contain measures to trigger building renovations. The EPBD defines the energy performance levels that have to be reached when a new building is built or when an existing building undergoes a major renovation, but it does not trigger additional renovations. Stakeholders also recognised that the EPBD framework was inadequate. In the consultation on the inception impact assessment, several stakeholders across all categories indicated the need for the EPBD to include additional measures to (radically) increase the rate of renovations in order to help achieve the decarbonisation objectives.

The energy performance trend in buildings depends on the combination of the quantity of building renovations (renovation rates) in EU countries and the quality of the energy efficiency improvements achieved by single renovations (renovation depth)[37].

Based on the latest available data, 11% of the existing building stock in the EU undergoes some level of renovation each year[38]. This means that in terms of floor area affected, the annual renovation rate appears to be at a satisfactory level. However,

---

[36] This was identified in particular across many Member States by an European Court of Auditors' special 2020 report on 'Energy efficiency in buildings: greater focus on cost-effectiveness still needed' in relation to an audit on cohesion policy spending on energy efficiency renovations in buildings, https://www.eca.europa.eu/Lists/ECADocuments/SR20_11/SR_Energy_efficiency_in_buildings_EN.pdf

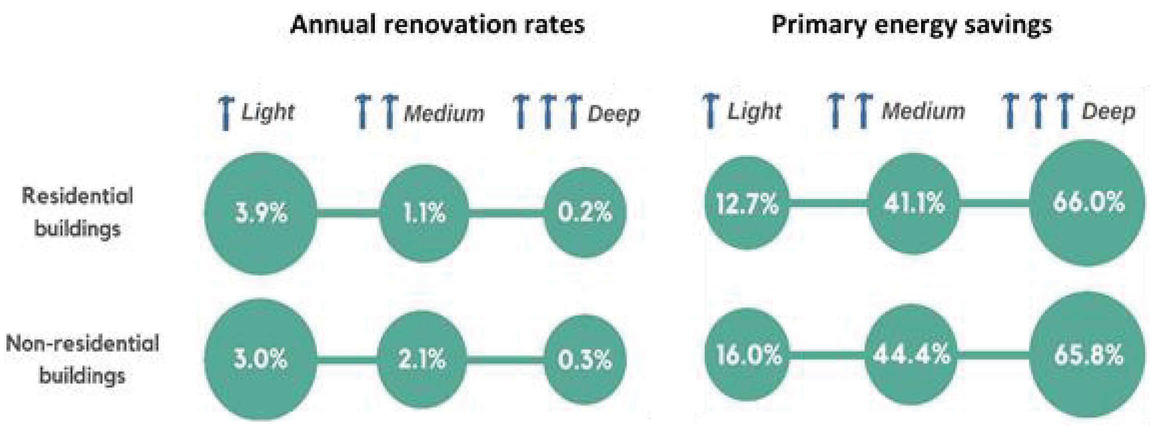
[37] Energy efficiency improvements during renovation can be realised either in the building envelope (walls, roof, windows, etc.) or in the technical building systems (hot water production, space heating/cooling, etc.).

[38] https://ec.europa.eu/energy/sites/ener/files/documents/2.annex_to_final_report.pdf

renovation works seldom address the energy performance of buildings, and the weighted annual energy renovation rate[39] at EU level is only around 1%. This applies to residential and non-residential buildings, including public buildings, with only marginal differences. This rate, if maintained, is not compatible with the achievement of the 2030 energy and climate goals, as illustrated in the Climate Target Plan analysis[40].

Figure 2.1 illustrates that the current level of annual renovation rates tends to favour building renovation with small primary energy-saving impacts overall (light renovations), while a wide range of technologies that would allow for much deeper renovations are available. Only a residual share of building interventions therefore target medium and deep energy renovations, which are able to achieve more than 40% and 60% primary energy savings respectively.

Figure 2.1: Annual energy renovation rates and corresponding average primary energy savings per intervention in the EU (2012-2016 average)[41]



For households, renovation is ultimately a private decision that is driven by several considerations. These often do not relate primarily to energy efficiency improvements but rather to the comfort, functionality, aesthetic and structural resilience of a building. For professional operators, the decisions can be based on more commercial considerations. Without appropriate regulations and increased awareness of the numerous benefits of energy renovations (indoor comfort, reduced energy needs, higher property value), several opportunities to greatly improve buildings will be missed. Similarly, financial institutions often express difficulties with navigating the technical aspects of

[39] The term 'weighted annual energy renovation rate' refers to the annual reduction of primary energy consumption in the total building stock achieved through the sum of energy renovations at all depths (light, medium and deep).

[40] The low renovation rate was a significant concern highlighted during the consultation on the inception impact assessment. In 62 responses, stakeholders called for an increased renovation rate of at least 2% or 3%. Most of this feedback came from business associations/companies, followed by NGOs.

[41] Esser, Anne; Dunne, Allison; Meeusen, Tim; Quaschning, Simon; Wegge, Denis; Hermelink, Andreas et al. (2019b): Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU. Final report - Infographics. Research report prepared for European Commission, DG Energy. (Ipsos); (Navigant).

renovations and their financial benefits. As a result, there is a lack of understanding, which would be necessary to offer targeted instruments such as favourable loans to building owners that plan to undertake renovations that also cover energy improvements.

Across the building stock in the EU, the worst performing buildings, i.e. buildings in the lower energy performance classes, are responsible for a large share of energy consumption and GHG emissions. However, despite this relatively high impact, the number of renovations among the worst performing buildings is lower than the average. There are several reasons for this: on the one hand, the lack of upfront capital and targeted funding and technical assistance tailored to buildings that require a more complex package of renovation measures, while investments in building renovations tend to prioritise single measures with relative short payback. On the other, worst performing buildings, both in the residential and service sector, are often rented out, meaning that the barrier of split incentives between owners and tenants to renovate buildings applies[42].

2.3.2 The drivers of the first key-problem.

Based on the general analysis of barriers to energy renovation in buildings in Section 2.2, the EPBD can address several but not all barriers to energy renovation. The problem drivers related to the first key problem that the EPBD revision will address are as follows (also detailed in Annex E):

- Split incentives
- Lack of information on the energy performance of buildings and multiple benefits of energy renovations
- Lack of standardised information tools on energy performance
- Lack of well-communicated decarbonisation trajectory
- Public financial support not sufficiently targeted towards deep renovations
- Behavioural barriers.

The issue of split incentives, or ‘owner-tenant dilemma’, is a very well-known barrier to the uptake of energy renovations in buildings. On the one hand, this affects the financial case for the energy renovation of rented buildings and the possibility to stimulate enough interest in energy renovations of such buildings by splitting its two main economic benefits: increase in property values and reduction of energy costs. Building owners would be required to pay for efficiency investments, while building occupants would

[42] The concept refers to the situation where the building owner pays for energy retrofits, but cannot recover savings from reduced energy use because they accrue to the tenant (who pays a lower heating bill). Unless the heating is included in the rent, in which case the property owner has an incentive to renovate worst performing buildings.

reap the benefits of lower energy costs. In parallel, the advantage for building owners in terms of property values would be directly accessible only through the increase in rents. This would not be possible in the short term and/or would have relevant economic and social impacts in terms of rent increases for tenants. This is why, in the absence of mandatory obligations and dedicated support to building renovations, the issue of split incentives probably remains one of the most relevant barriers to the uptake of energy renovations in buildings through market measures. The EPBD currently does not include any specific measures to address the lack of incentives for landlords to renovate.

There is a significant lack of information and awareness from both private, public (such as municipalities, the public health sector, social housing) and professional owners or tenants of buildings on the overall energy performance of the buildings they own or live in, possible energy efficiency improvements, costs and benefits, carbon performance and options to decarbonise. Although energy performance certificates (EPCs) regulated by the EPBD are well-recognised tools and provide some of this information, which is also valued by the market[43], the coverage, diffusion and proper advertisement of EPCs is relatively low.[44] 65% of the respondents to the public consultation indicated that EPCs should be updated and their quality improved. Stakeholders criticised the current EPCs for appearing inadequate, with sub-optimal rating methodologies and poor recommendations for improving cost-effective energy performance. They also highlighted the low reliability of the data provided by EPCs, questioning the quality of the calculation methods or of the audits. EPCs are only required at specific moments in the lifetime of a building (sale or rent for the majority of buildings, while public buildings of a certain size should always have a valid EPC and display it). This never happens for many buildings during their life cycle. In addition, the information on EPCs remains limited and is not sufficient to illustrate all the qualities and technologies of buildings nor the full range of benefits that improvements could bring. Carbon performance is for instance not a compulsory element in EPCs. The content of EPCs and the EPC classes attributed to buildings also vary significantly across countries. This limits their value to investors and financial players that operate in multiple markets. In this respect, 75% of the respondents to the public consultation acknowledged the issue.

Closely linked with the information and technical barriers, public financial support for energy renovations are currently also not sufficiently targeted towards deep renovations. In particular, there is a clear link between the lack of appropriate and standardised information tools for building renovations and the difficulty in targeting public financial support towards deep energy renovations able to deliver large benefits in terms of energy

[43] Several studies indicate that a price premium is applied to the most energy-efficient properties, for instance https://doi.org/10.1016/j.apenergy.2016.07.076
[44] See Annex G on EPCs.

consumption and GHG emission reductions[45]. At the same time, regulatory measures are needed to provide the necessary legal certainty, clarity and direction to better guide financial investors and public support schemes. In that respect, the current framework lacks clear definitions of deep and staged renovations[46].

Behavioural barriers, including risk aversion and inertia, are also key drivers behind low renovation rates, at a level that fails to exploit the techno-economic energy efficiency potential of buildings.

2.3.3 The complementary role of regulatory measures and carbon pricing to address the barriers to energy renovations

As illustrated in the previous section, multiple factors hamper the roll-out of energy renovations, and not all of them can be addressed by the EPBD. The policy mix of measures included in the 'Fit for 55' package includes elements able to address the different drivers, in particular carbon pricing, non-regulatory signals (such as targets), regulatory measures, information tools, standards and support measures.

The strengthening of the EPBD and its revision will address measures that are mainly regulatory, including information tools and planning. Current experiences with the EPBD show that the regulatory approach is effective in increasing the energy performance of buildings and in scaling up construction activities and the market uptake of materials, products and highly performing technologies necessary to meet the regulatory levels. The review will deepen the successful policies, leading to higher energy performance levels for new buildings and extending them to existing buildings.

One key complementarity exists in the legal framework between carbon pricing mechanisms and regulatory instruments in the building sector. While the carbon price acts as a key tool in delivering rapid decarbonisation both in the buildings and transport sector, market failures and barriers affecting the building sector would remain unaddressed without regulatory measures and investment support.

The EU Emissions Trading System (EU ETS) currently covers around 30% of building emissions from heating[47]. This is related to the system's coverage of district heating and electricity used for heating purposes. These are direct emissions from larger fossil fuel

---

[45] This aspect was in particular underlined by the European Court of Auditors' recommendations as part of their special report on 'Energy efficiency in buildings: greater focus on cost-effectiveness still needed', https://www.eca.europa.eu/Lists/ECADocuments/SR20_11/SR_Energy_efficiency_in_buildings_EN.pdf

[46] Staged renovation is a deep renovation delivered in steps, in several packages of measures and over a period of time (e.g. replacing windows in a year, insulating walls a few years later, replacing the boiler after another few years). In this way, the investment costs are distributed over a period of several years, when building owners also benefit from the corresponding energy cost savings from the implemented measure. This makes deep renovations more feasible and affordable. Staged renovations are facilitated by the introduction of the building renovation passport.

[47] This percentage refers to both direct and indirect emissions.

district heating system installations included in the EU ETS (> 20 MW) and indirect emissions from electricity use in appliances, heating and cooling equipment such as heat pumps and lighting. The carbon price from the existing EU ETS is largely passed onto consumers via their electricity bill and heating costs. However, its price signal is limited as not all fuels are covered.

With the proposed extension of ETS to heating fuels as part of the 'Fit for 55' package, all heating fuels will be subject to a carbon price. Consumer heating bills will therefore internalise carbon costs, indirectly incentivising the shift towards low-carbon heating and investments in solutions that reduce energy consumption and exploit the existing energy efficiency potential in the building sector.

Adding to heating costs derived from fossil fuels, the carbon price acts as an economic incentive and makes investments in low-carbon heat and energy efficiency more cost-effective. An ETS extension and higher costs for heating buildings with fossil fuels would result in an additional economic incentive for the energy efficiency measures promoted by the EPBD and the EED, provided that the carbon price signal is sufficiently high. If the price is set at a sufficiently high level, energy efficiency measures would likely become more cost-effective and have a shorter payback period.

The non-rational response of economic agents and the effects of non-economic barriers and market failures, which prevent the markets alone from delivering cost-effective emission abatement solutions, are illustrated by price elasticities – 'the higher, the bigger' being the response[48]. Price elasticities vary from short-term (reflecting the fact that behavioural responses to changes in prices are small as space heating is a necessity) to long-term ones (reflecting the factors that constrain investment).

Price elasticities of consumers to the costs of heating in the residential and service sector are not well documented, but are considered to be low based on the studies available. In the building sector, the information available from the literature is very limited. However, the results indicate that buildings' total energy consumption has a long-term price elasticity of -0.23 on average at EU level[49]. The presence of low elasticities indicate that even if there is a significant carbon price, an abatement decision will not be taken, and that a very high price is needed in the absence of complementary regulatory measures. These constraints may prevent energy consumption from responding to a carbon price signal quickly and strongly enough. Especially in case of low price signals,

[48] Estimates of the price elasticity of demand represent the factor by which the demand for a good or service changes in response to a 1% change in its price. Price inelastic goods have a price elasticity between -1 and 0, with goods being classified as more inelastic the closer their elasticity estimate is to zero.
[49] ICF (2021) ETS Clima study. Other studies show that empirical estimates of the short-run price elasticity of demand for heating fuels in Europe range from -0.025 to -0.26, with long-run estimates ranging from -0.05 to -0.32 for fossil gas and -0.025 to -0.50 for electricity.

carbon pricing alone would be insufficient to drive the uptake of the cost-effective carbon abatement actions in the building sector.

The following tables present the abatement ($MtCO_2$) and energy savings (Mtoe) potential respectively in the residential sector in 2030 for the EU-27, at different carbon prices.

Table 2.2 Marginal energy savings (Mtoe) for residential building sector within EU-27 in 2030[50]

2030	ENERGY CONSUMPTION (MTOE)	ENERGY SAVINGS POTENTIAL (MTOE)	% SAVINGS POTENTIAL
Carbon price 0 (EUR/tC02)		16.1	8%
Carbon price 30 (EUR/tC02)		16.9	9%
Carbon price 50 (EUR/tC02)		17.1	9%
Carbon price 90 (EUR/tC02)		20.6	11%
Carbon price 150 (EUR/tC02)		21.2	11%

Table 2.3 Mitigation measures implemented at each carbon price[51]

CARBON PRICE 0 (EUR/TC02)	ADAPTIVE THERMOSTATS ADVANCED POWER STRIPS RET ADVANCED POWER STRIPS AIR INFILTRATION CENTRAL AIR CONDITIONER TUNE-UP CENTRAL FURNACE EFFICIENT FAN MOTOR CENTRAL HEAT PUMP TUNE-UP CONDENSING GAS BOILERS AND WATER HEATERS INSULATION (DRAFT PROOFING, DUCT SEALING, PIPING) EFFICIENT APPLIANCES (REFRIGERATOR, CEILING FANS, DEHUMIDIFIERS, CLOTHES WASHER AND DRYER, TELEVISION, WINDOW AIR CONDITIONER) HEAT PUMPS (ELECTRIC AIR-SOURCE COLD CLIMATE, GROUND SOURCE) ENERGY EFFICIENT HOMES (20% ABOVE CODE) ENERGY EFFICIENT POOL PUMPS LIGHTING EFFICIENCY (EXTERIOR, CFL, INCANDESCENT) WATER APPLIANCES (FAUCET AERATORS, LOW FLOW SHOWER HEAD) WATER HEATER (HIGH EFFICIENCY GAS STORAGE WATER HEATER, HYDRONIC HEATING, TANKLESS) HIGH EFFICIENCY WINDOWS SOCIAL BENCHMARKING AND HOME ENERGY MONITORING
Carbon price 30 (EUR/tC02)	Crawlspace insulation Early furnace replacement - 70% AFUE - 90% AFUE
Carbon price 50 (EUR/tC02)	Integrated heating and domestic hot water (forced air heating)
Carbon price 90 (EUR/tC02)	Insulation (attic/ceiling, basement wall (R-12), slab (unfinished basement) High efficiency heat recovery ventilators (HRVs) Water heater replacement
Carbon price 150 (EUR/tC02)	95% or higher efficiency furnaces Active solar water heating systems

[50] Source: ICF Consulting.
[51] Source: ICF Consulting.

The analysis in the above tables shows that at higher carbon price levels, more expensive measures – but also more rewarding ones in the longer term – will be adopted. This is also illustrated in the modelling scenarios underpinning the ‘Fit for 55’ package. With carbon price alone, at the level estimated in the MIX scenario of EUR 48/tonne in 2030, several measures necessary to exploit the energy efficiency potential will not take place, leaving untapped potential.

The ‘Fit for 55’ package therefore envisages a mix of instruments to address economic and non-economic barriers in a complementary way, together with financial support. In this framework, regulatory measures are crucial to driving demand for decarbonisation solutions and to addressing structural barriers. The EPBD revision aims to strengthen the current measures and introduce new ones to address the persistent barriers to energy renovation, in complementarity with carbon price signals, other regulatory instruments envisaged in the Energy Efficiency Directive, Renewable Energy Directive and the mechanism in the Effort Sharing Regulation.

Standards are needed to direct renovations towards buildings with the highest potential and at the same time with the highest structural barriers of risk aversion, split incentives and information asymmetry, and to stimulate more complex deeper renovations. The carbon price is in fact expected to be effective in driving light renovation, but it would have limited effects on medium to deep ones. According to the analysis made in the Climate Target Plan and confirmed in the scenarios underpinning the ‘Fit for 55’ legislative proposals, it would need to increase six times from the level estimated of 0.1% each year in the REF baseline scenario.

*2.3.4 **The second key problem**: The EPBD framework is insufficient for the 2050 climate objectives and to foster energy system integration*

Net zero emission buildings have been identified as a key enabling pathway needed to deliver on climate neutrality[52]. While the EPBD, through national long-term renovation strategies, already requires planning towards decarbonisation, there is a lack of a clear pathway to deliver on climate neutrality. There is currently a lack of a coherent framework to allow Member States to develop and plan their building decarbonisation pathway in more detail, with clear milestones and targets towards 2030 and 2040. While around 85 million m² of residential buildings and 40 million m² of service buildings are built each year in Europe[53], the current EPBD requirements for new buildings do not ensure that buildings are built in a way that makes them fully decarbonised (‘2050-ready’).

---

[52] ‘A Clean Planet for all: A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy’, COM(2018) 773 final.

[53] Estimates based on the Odyssee database: https://www.indicators.odyssee-mure.eu/energy-efficiency-database.html

With reference to the pathway towards climate neutrality, existing buildings with poor energy performance are characterised by high energy consumption, high GHG emissions and often relatively poor integration in the energy system. In the majority of cases, worst performing buildings are usually the ones that rely more heavily on fossil fuels for heating and cooling, and where the uptake of renewable energy sources is more difficult because of the poor quality of the technical building system. Even if the building's energy demand could be fully covered by renewable energy, the low energy efficiency of the building would lead to a waste of energy resources.

As a consequence, the current building stock is not always 'technically fit' for the energy transition and ready to be integrated into a decarbonised and digitalised energy system. This is a major barrier to the decarbonisation of heating and cooling and to increasing the uptake of energy from renewables (i.e. geothermal heat) in households. A more energy-efficient building stock is often a prerequisite for the energy switch for heating and cooling from fossil fuels to renewable energy sources. In addition, there are also similar technical and administrative barriers in the existing building stock. This hampers the uptake of e-mobility solutions because of the lack of charging points in residential and private buildings.

2.3.5 The problem drivers of the second key problem

- Lack of standards and requirements for new and existing buildings in line with decarbonisation goal.

The current definition for nearly zero-energy buildings (NZEB) in the EPBD was developed over 10 years ago and does not reflect the goal of decarbonisation and zero carbon buildings enough. In addition, NZEB energy consumption levels differ across Member States[54] and do not address whole-life carbon nor the readiness of buildings to provide flexibility and play an active part in the energy system by integrating smart solutions for storage and demand response/management services to the grid. On these aspects, 57% of the respondents to the public consultation indicated that NZEBs are not ambitious enough.

- Insufficient measures to facilitate the integration of digitalisation and smart solutions in new construction and building renovations.

Digitalisation is a key enabler in the decarbonisation of the building stock. Digital technologies that can be used across the life cycle of buildings, from design and construction to operation, are still not appropriately established in the EPBD framework and in the renovation processes.

First, it has great potential to increase the quality and scalability of energy efficiency solutions, with optimal design and collaboration (for example, building information

[54] See Annex H.

modelling), execution (for example, automated construction techniques), and use of buildings (for example, automated management systems, controllable devices and smart appliances, and data collection). Second, in line with the energy system integration strategy, it gives building users smart and flexible energy services, allowing the development of demand-side management strategies that help further integrate variable and decentralised renewable energy sources into the energy system, as well as energy storage technology. However, the appropriate framework is still not in place for the energy demand side to increasingly contribute to the smart energy grid flexibility effort. Third, digitalisation can enable better resource efficiency and facilitate circular approaches during design as well as construction and renovation. These are essential for lowering embodied emissions and achieving climate neutrality in buildings.

Digitisation is a topic that was often highlighted by stakeholders as requiring targeted measures in the EPBD. Stakeholders underlined its contribution to greater efficiency, transparency of information, flexibility of the energy system and therefore reduction of emissions. To complement this, in the public consultation conducted between 30 March and 22 June 2021[55], 72% of the respondents expressed the view that the EPBD can contribute to making available and accessible a wider range of building-related data on the energy performance of buildings and its related construction and renovation works across its life cycle.

- Insufficient measures to support the uptake of electro mobility in private buildings.

Current requirement for new buildings do not seem adequate to address existing barriers and support the uptake of sustainable mobility and to contribute to transport decarbonisation. With currently up to 90% of electric vehicles[56], recharging taking place at home or at the workplace, the role of buildings in providing recharging infrastructure is crucial, alongside publicly accessible infrastructure, which is regulated in the Alternative Fuels Infrastructure Regulation (AFIR). The share of recharging at publicly accessible points is expected to increase after 2030, but between 60% and 85% of all recharging will still take place at private recharging points[57]. According to a recent study, the lack of deployment of smart private recharging infrastructure is a barrier[58] to the development of the market for EVs. Lengthy and complex approval procedures can be a

[55] The public consultation attracted a total of 535 participants. The majority of people are from the EU (81 responses). Two respondents declared to be non-EU citizens. Most of the responses came from companies/business organisations and business associations (278 responses, 52%), followed by academic institutions (16 responses, 3%). 39 responses were from public authorities (7%), NGOs (12%), trade unions (5 responses, 2%), environmental organisations (1%) and consumer organisations (1%). 35 declared to be other stakeholder type (7%).

[56] "Electric vehicles" (EV) are meant to include the range of vehicles of different sizes and concepts, including also electrically assisted bicycles, as long as they are powered by electricity.

[57] https://ec.europa.eu/info/sites/default/files/revision_of_the_directive_on_deployment_of_the_alternative_fuels_infrastructure_with_annex_0.pdf

[58] Study ENER-B3-2020-332.

major barrier to owners and tenants installing recharging points in existing multi-tenant residential and non-residential buildings. Obtaining the necessary approvals can create delays or prevent their installation.

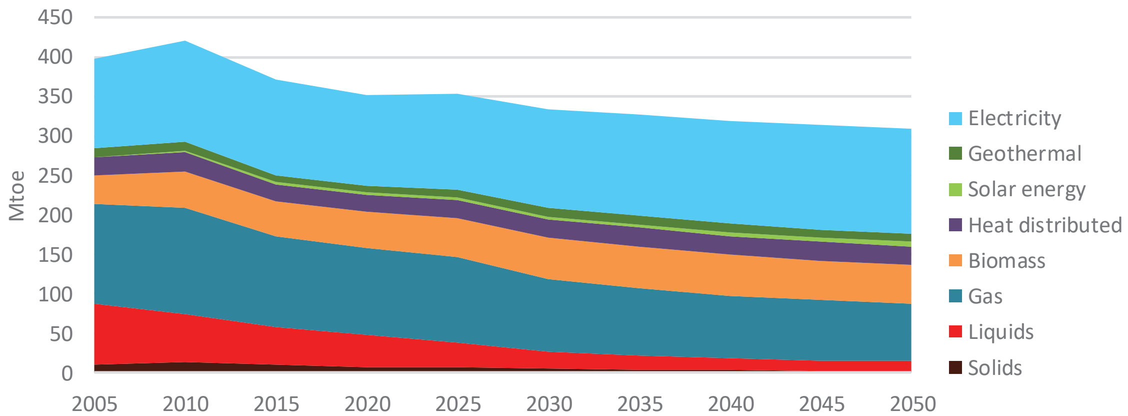
2.4 How will the problem evolve?

2.4.1 The building sector in the Reference scenario

The magnitude of the challenge ahead, caused by the current inefficiency and low rate of renovation and decarbonisation of Europe's building stock, is illustrated by the CTP's impact assessment and the updated scenarios drawn up in other proposals of the 'Fit for 55' package. The current decrease of CO2eq emissions from the use of buildings is estimated to be maximum 1%/year. This is three or four times lower than what would be necessary to sufficiently contribute to the '-55% by 2030' target.

In the baseline of the 'Fit for 55' package (REF), which describes 'business as usual' conditions and evolution based on current policies, primary energy consumption decreases by 32.7% in 2030, but this is insufficient for the net -55% climate target. For final energy consumption, REF projects 823 Mtoe, which is 29.6% below the trajectory of the 2007 baseline and therefore below the agreed 2030 energy efficiency target of at least 32.5%[59].

Figure 2.2: Final energy consumption by fuel in buildings (residential and services)[60]



The use of buildings is responsible for more than 40% of final energy consumption[61]. Residential and service buildings consume 333 Mtoe together each year, with residential

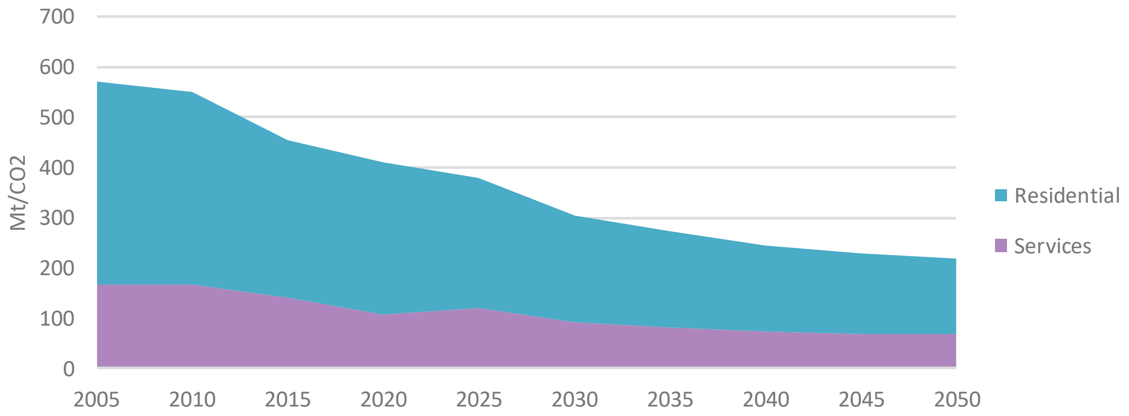
[59] The 2030 energy efficiency target has been realigned with the values of the 2020 reference scenario. On this basis, the current 2030 target can be expressed as a reduction of 9% of final energy consumption in comparison to the level in 2020 reference scenario (REF).

[60] Eurostat and PRIMES model.

[61] This figure refers to the use and operation of buildings, including indirect emissions in the power and heat sector, but not their full life cycle. The embodied carbon in construction is estimated to account for around 10% of total yearly greenhouse gas emissions worldwide, see IRP, Resource Efficiency and Climate Change, 2020, and the UN Environment Emissions Gap Report.

buildings representing almost 65% of the total. Figure 2.2 displays the combined consumption of residential and services in buildings in REF by fuel type.

Figure 2.3: GHG emissions from the use of buildings[62]



In the REF scenario, energy consumption for the use of buildings already falls significantly thanks to policies already in place and better performance and lower costs of technologies (such as heat pumps). However, their effects are partially offset by increased consumption to satisfy higher comfort levels and increased demand also for cooling needs. Looking towards 2050, the importance of fossil fuels decreases and electricity expands its already significant share further. However, solar energy and distributed heat remain marginal. Figure 2.3 displays the projected decline in GHG emissions.

Both residential and service sectors need to reduce their emissions. Due to their share in energy consumption, residential buildings in terms of absolute amounts have to make a bigger effort to reduce emissions than service buildings. The EU's total GHG emissions in the REF in 2030 (including all domestic emissions & intra-EU aviation and maritime) will be 43.8% below the 1990 level. Climate neutrality will not be achieved in the baseline, falling short of the European Climate Law objective.

2.4.2 The need for a more efficient building stock in a progressively decarbonised energy system

In the CTP and the 'Fit for 55' package, REG and MIX 'core' scenarios[63] illustrate the need to step up efforts in comparison to current trends across all sectors. Depending on the policy mix, 'core' scenarios achieve a significant decarbonisation of building stock

---

[62] Eurostat and PRIMES model.

[63] See the discussion in Chapter 6 and description of core scenarios here: https://ec.europa.eu/energy/data-analysis/energy-modelling/policy-scenarios-delivering-european-green-deal_en as well as Annex 4 in the impact assessment accompanying the amendment to the Renewable Energy Directive, SWD(2021)621 final.

through a fuel switch combined with energy efficiency progress thanks to renovations and the use of more efficiency appliances.

For the decarbonisation of buildings, the reductions needed by 2030 range between -54% and -61% (compared to 2015) in the scenarios for achieving -55% GHG. This is a step change in comparison to the reference scenario in which the level of GHG reductions is -33% in 2030.

The reasoning behind the significantly higher cost-effective emission reductions for buildings (and the power sector) compared to other sectors in modelling is that buildings have greater potential for abatement at a lower cost and therefore compensate for other 'hard to decarbonise' sectors. Those sectors are unlikely to level off their expansion and growth trends by 2030 with the increased speed of decarbonisation (e.g. transport, heavy industry that needs technologies such as hydrogen) or to simply achieve a similar level of emission reductions technically (e.g. agriculture, which has very few abatement options).

The power sector also has greater potential and needs to significantly cut its direct emissions too. In the long term, it will be one of the first to decarbonise completely. Furthermore, a strong link exists with the building sector due to the significant trend towards electrification of heating via heat pumps. To some extent (given that heat pumps are very efficient in electricity consumption and electricity is the sector that decarbonises the fastest), with the electrification of heating, direct emissions from buildings are 'moved' into the power sector, e.g. by replacing fossil fuel boilers with heat pumps (which run on electricity).

Importantly, core scenarios show that in the absence of energy efficiency, the effort in terms of fuel switch needs to be bigger. This effect would exacerbate climate neutrality pathways, leading to a strain on scarce resources (biomass-based fuels for heating or hydrogen-based innovative synthetic fuels).

To avoid a certain sectoral shift of emissions from buildings to power generation in the medium term or too high demand for low-carbon H&C in the long term, energy needs therefore need to be reduced, together with phasing out the remaining fossil fuel consumption.

Analysis and projections converge, indicating that a cost-effective and feasible pathway towards decarbonisation should rely partly on the decarbonisation of power generation, partly on low-carbon fuels, including the direct use of renewables in buildings (on-site), and partly on reducing the energy needs in key energy consumption sectors. The optimal pathways towards decarbonisation balance renewable deployment and energy efficiency improvements across the energy sectors. In long-term EU scenarios, achieving carbon neutrality[64], demand-side solutions and, in particular, high-performance buildings plays a critical role in reducing the demand for electrical heating in winter, addressing the

[64] In-depth analysis in support of Commission Communication COM(2018).

seasonal supply-demand mismatch. In particular, the temporal mismatch between the non-dispatchable renewable supply and peaks in electricity demand is in fact one of the key challenges to achieving high percentages of renewable electricity supply. Minimising the space heating requirements through the building envelope and its air tightness performance while covering the remaining energy demand by renewable sources, especially electrification, has been identified as an optimal strategy to ensure grid balancing and to find the cost-optimal pathway towards decarbonising the energy sector[65]. While this is true at aggregate level, also at the level of single buildings, analysis shows that while comparing new constructions implementing the NZEB requirement in order to minimise life cycle costs and the environmental impacts across their life cycle, buildings with higher energy performance outperformed those for which electricity production was maximised[66]. Such analysis suggests that the focus should be placed on (i) minimising the space heating requirements through a building envelope with high thermal and air tightness performance; and (ii) covering the remaining energy demand, to a significant extent, by renewable sources that compensate for buildings' specific energy source during their operational phase.

3. WHY SHOULD THE EU ACT?

3.1 Legal basis

The legal basis is Article 194(2) TFEU, the legal basis for Union policy to promote energy efficiency and energy savings. Energy policy is a shared competence between the EU and Member States. As this initiative concerns amendments to an existing Directive, only the EU can effectively address the issues.

3.2 Subsidiarity: Necessity of EU action

Climate change being a transboundary problem, Member States' action alone on buildings' emissions would lead to suboptimal outcomes.

To decarbonise the buildings stock, its annual rate of refurbishment must be scaled up. Low renovation rates are also linked to the underachievement of the energy efficiency goals in 2020, as energy consumption in the buildings sector has not decreased along a pathway compatible with it. The issue of insufficient rates and depths of renovation to achieve the GHG reduction objectives is a common one in the EU. As mentioned in the Renovation Wave Communication, across the EU, deep renovations that reduce energy consumption by at least 60% are carried out only in 0.2% of the building stock per year and in some regions, energy renovation rates are virtually absent. No Member State achieves a yearly deep renovation rate of 1% or more. Similarly, yearly rates of medium renovation (30% or more of primary energy savings) are below 5% in all Member States when looking at both residential and non-residential buildings. Those consistently low

[65] See for instance https://doi.org/10.1016/j.enpol.2021.112565
[66] https://doi.org/10.1016/j.enbuild.2017.01.029

renovation rates show that a step change towards stronger requirements at EU level is needed.

In addition, as laid down in Chapter 2 and in Annex E, the underlying problem drivers and relevant barriers to building renovations, such as market failures (notably split incentives owner-tenant-dilemma), information barriers, organisation and behavioural barriers, lack of targeted finance and technical capacities and skills, prove to be similar in all EU Member States. These economic and non-economic barriers are largely present in all Member States and cannot be overcome solely with economic or monetary incentives. This is acknowledged in the set-up of the 'Fit for 55' package which includes a reasoned policy mix of targets and non-regulatory signals, carbon price mechanisms, regulatory standards and financial incentives.

If buildings were not to be decarbonised in an effective and coordinated manner across the EU, this would lead to an unfair distribution of burden and a spillover effect of higher energy consumption and greenhouse gas abatement costs for the EU as a whole. A key underlying reason is the increasing marginal cost of GHG emission abatement, including for investments targeting buildings' energy performance. The more a building or building stock is already energy performant (because of high insulation and low-carbon heating already installed), the more difficult and thus costly it becomes to tap into additional energy and GHG savings. The fragmentation of the buildings' energy performance, leading to shares of inefficient buildings in certain Member States not being targeted (low-hanging fruits) could therefore lead ultimately to a possible failure in meeting the long-term EU decarbonisation objective, but also reduced energy security due to higher energy consumption

More ambitious and more prescriptive EU level action is therefore necessary to ensure policy alignment towards decarbonisation of buildings across the EU. The role of the EU is crucial to make sure that the regulatory framework reaches comparable ambition levels and is consistently enforced. The revision of the EPBD follows the need to update it to reflect the increased ambition of the EU climate and energy targets. This is on top of the fact that the assessment of the EU-wide impact of the National Energy & Climate Plans that the Commission published in September 2020[67] showed an ambition gap as regards energy efficiency: 2.8 percentage points for primary energy consumption and 3.1 points for final energy consumption in the EU, as compared to the 2030 goals currently in force. Further EU wide measures in the revised EPBD would thus be needed in any case in line with what foreseen in the Energy Union Governance Regulation[68].

---

[67] https://ec.europa.eu/info/news/commission-publishes-assessment-national-energy-climate-plans-2020-sep-17_en

[68] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R1999&from=EN

3.3 Subsidiarity: Added value of EU action

Setting a common framework for the enhanced decarbonisation of buildings at EU level will ensure that the buildings sector reduces its GHG emissions at the required scale to achieve the EU's energy and climate targets and in the most cost effective way.

Since the adoption of the first EPBD in 2002, the EU legislative framework on buildings' energy performance has prudently expanded, setting a common minimum framework at EU level and leaving significant flexibility for implementation and adaptation to Member States. The experience with joint EU ambition for all new buildings to be nearly zero-energy by 2020 shows the significant impact of mobilising the buildings sector around a common objective and language[69]. Nonetheless, so far similar market signals have been missing for the existing building stock, which represents the largest share of the cost-effective potential[70]. Action at EU level offers a better leverage in mobilising the sector around a common ambition and leads to higher expected market outcomes. The development of industrialised fast-track solutions for the uptake deep energy renovations and zero-emission buildings would benefit from a closer integration of the EU market for energy renovations and sustainable constructions. In order to achieve these objectives, common framework and methodologies on the evaluation of energy performance of buildings and renovation practices have to be established at EU level. The experience from the implementation of the current EPBD shows that a common EU framework allows national policy-makers to build on each other's' best practices, stimulates innovation and increases the benefits of the internal market for construction products and appliances. Additionally, differences in the current national frameworks for monitoring and evaluation of energy performance of buildings prevents the possibility to exploit synergies and economy of scale for cross-border professional and financial investors in energy efficiency renovations of buildings. Today, the absence of a common EU framework methodology and of national databases on energy performance frameworks is identified as relevant to the uptake of private financing for energy renovations.

Construction products and services, heating, cooling, air-conditioning and lighting devices, as well as on-building renewable systems, smart controls, building automation systems, smart meters, and other products are an important part of the internal market. The construction sector overall contributes to 9% of the EU's GDP. A joint EU framework for building renovation will send strong market signals that promote the development of these markets and will lead to economies of scale. In relatively new areas such as industrialised solutions for building renovation, strengthening the common

[69] See Annex H and ongoing Horizon 2020 projects (e.g. RenoZEB, HEART, REZBUILD, ReCO2ST).
[70] This is assessed in various studies, including: (ICF et al.; 2021); *Technical assistance services to assess the energy savings potentials at national and European Level*. See also Annex H of the Impact Assessment supporting the revision of the EED: https://ec.europa.eu/info/sites/default/files/proposal_for_a_directive_on_energy_efficiency_recast.pdf .

language and requirements will help the EU industry expand. Consulted stakeholders underlined the importance of common standards and access to information for the scalability of innovative projects (e.g. turnkey renovations, which benefit from transparent access to information on permits and financing sources). On financing specifically, having a common definition of 'deep renovations' will allow investors to aggregate funding to be channelled to projects which meet the deep renovation criteria.

Action to upgrade the energy performance of the existing building stock will also generate other common EU benefits. As an example, the reduced energy demand from buildings and higher reliance on renewable energy, which is overwhelmingly generated within the EU, will contribute to the security of energy supply for all EU Member States.

Changes to the current EPBD framework do not mean that no margin for manoeuver will be left to Member States. Building typologies, ownership structures, climatic conditions and energy poverty levels vary across Europe. Therefore, while the direction of travel and a common ambition level need to be set at EU level, sufficient flexibility is given to Member States in order to adapt their buildings regulatory and financing policies to national and local circumstances.

4. OBJECTIVES: WHAT IS TO BE ACHIEVED?

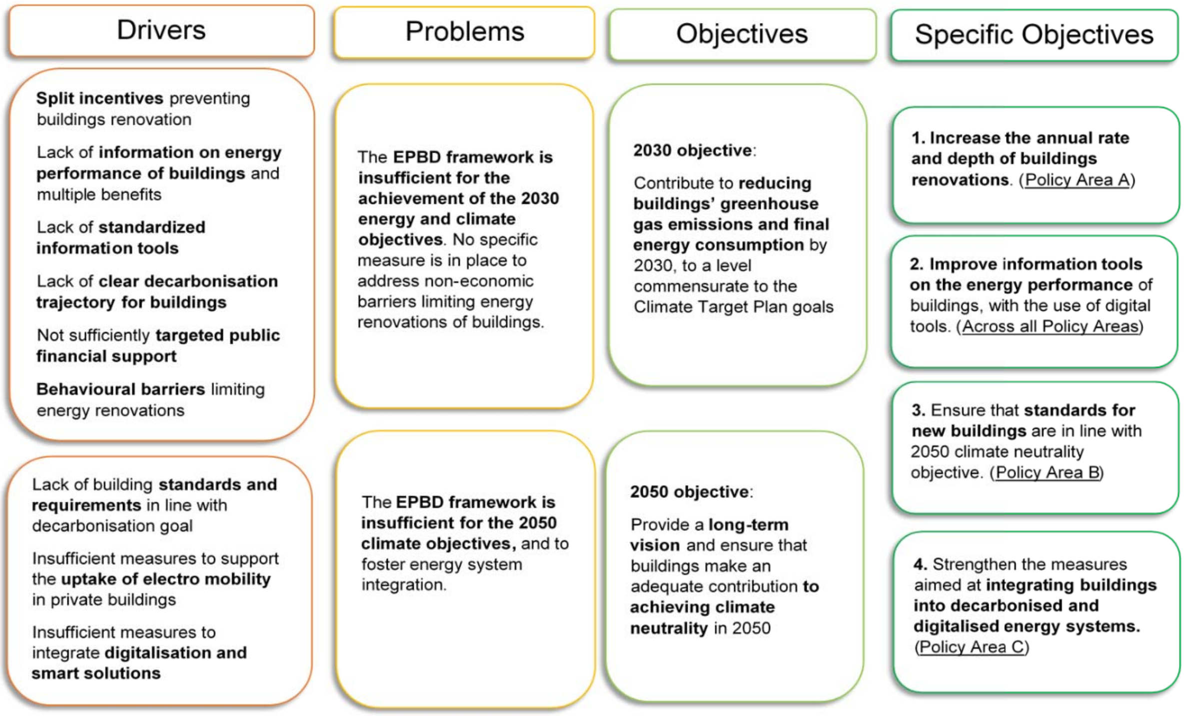
4.1 General objectives

Together with the other actions from the Renovation Wave action plan and the other elements of the 'Fit for 55' package, the revision of the EPBD aims to strengthen the legal framework for the energy performance of buildings to ensure a higher contribution to the achievement of the EU's energy and climate objectives for 2030 and the climate neutrality objective for 2050, in particular through a higher renovation rate.

The revision will also aim to modernise buildings and strengthen their role as an active part in the energy system, for instance through smart charging of EVs. The following figure provides an overview of the problems, drivers and objectives of the EPBD revision. In particular, two general objectives have been identified for this EPBD revision:

- **2030 objective:** Contribute to reducing buildings' greenhouse gas emissions and final energy consumption by 2030, to a level commensurate with the CTP goals.
- **2050 objective:** Provide a long-term vision and ensure that buildings make an adequate contribution to achieving climate neutrality in 2050.

Figure 4.1: Drivers, problems and objectives of the EPBD revision



In order to achieve the general objective and to tackle the key problems and problem drivers identified, four specific objectives that pave the way to the policy options (described in Chapter 5) have been identified. The specific objectives identified aim in particular to address, among the several additional drivers of a broader nature, those that can be directly tackled by the EPBD and contribute to the identified key problems.

As set out in Article 1 EPBD, the EPBD promotes the improvement of the energy performance of buildings within the EU. Several key elements of the Renovation Wave strategy, such as finance, adequately skilled workforce, seismic safety of buildings and safety of workers, fall outside the EPBD scope and cannot, or only to a limited extent, be addressed by the EPBD revision.

4.2 Specific objectives

4.2.1 Increase the rate and depth of building renovations.

The first specific objective addresses the first key problem and related problem drivers, namely the barriers identified to the increase of annual energy renovation rates and deep energy renovations. Increasing the renovation rates and the depth of building renovations is necessary to put the building sector on track towards achieving the 2030 energy and climate targets and the specific target contribution for decarbonisation efforts in buildings. To improve the energy performance of the EU building stock in the most cost-effective way, the scale of building renovations (renovation rates) in EU countries need to increase in parallel with the quality of the energy efficiency improvements achieved by the single renovation (renovation depth). Increasing the renovation rate and thereby realising the energy savings potential in existing buildings is important to cut carbon emissions, improve well-being and reduce energy poverty. The increased rate and depth of renovation should be commensurate with the decarbonisation efforts required to achieve the increased climate target and will have to be maintained also post-2030 in order to achieve EU-wide climate neutrality by 2050. Doing this with circularity in mind will reduce waste and keep embodied carbon low. Several stakeholders[71] supported this and called for 'greener' renovations that integrate circular economy principles.

The aim is to trigger, with updated policy measures, energy renovations at certain moments in the buildings' life cycle, or by addressing split incentives and the organisational barriers to energy renovations[72], also bearing in mind that by addressing the worst performing buildings the benefits are maximised. Improved information and comparability of the energy performance of individual buildings will also increase awareness and contribute to greater renovation efforts. This will also be addressed by strengthening the links between the depth of renovations and the aid intensity accessible through public budget support.

For this objective, there are synergies with the energy-saving goals, policies on the public sector, public building renovation and split incentives[73] in the EED and with the introduction of emissions trading in the building sector. It is supported by the ESR, which sets binding GHG emission reduction targets for Member States that cover several sectors, including buildings.

4.2.2 Improve information on the energy performance and sustainability of buildings, with the use of digital tools.

Improving information on the energy performance of buildings addresses multiple barriers to achieving decarbonisation of the building stock and the climate neutrality goal by 2050. This specific objective aims to address both key problems identified and the information barriers to the uptake of energy renovations and of a clear decarbonisation trajectory for buildings. It specifically addresses the problem drivers linked to the lack of information on the energy performance of buildings and multiple benefits of energy renovations and linked to a lack of standardised information tools on energy performance. By strengthening the reliability of the tools already available to measure the energy performance of buildings, the awareness of the general public as well as professionals of the multiple benefits that could be achieved thanks to deeper renovations would be improved and property values would reflect this.

Overall, the objective is to increase the number of buildings with an EPC, as well as their quality and comparability across Member States, and to further EPC mainstreaming and

[71] In the consultation on the inception impact assessment, 87 feedback responses covered the topic of circularity. These returns mainly came from professional associations/companies, NGOs and public authorities.
[72] doi:10.2790/912494, JRC101251
[73] doi:10.2760/070440, JRC115314

accessibility to consumers and investors. This increased coverage should go hand in hand with the higher quality of EPCs as fully digital tools. By increasing the quality and comparability of EPCs as fully digital tools, the aim is also to reduce the administrative burden for building renovations.

By increasing the scope, range of information and coverage of EPCs and other building information tools such as building renovation passports, the objective is also to ensure that public support such as EU funding can be better targeted towards high-impact projects and qualitative investments. This will also facilitate follow-up in terms of reporting and monitoring and the long-term impact of public support to building renovation. Digitalised EPCs and digital tools could reduce the administrative burden and simplify procedures.

Stakeholders stressed that improving the quality is key as only high-quality EPCs will be trusted by owners/occupiers and the finance sector. In particular, 77% of the respondents to the public consultation pointed out that funding support to renovations should be linked to the depth of renovations. They also underlined that EPCs are the key tool for assessing energy efficiency improvements for financing purposes. Alongside EPCs, stakeholders[74] largely supported the inclusion of the building renovation passport in the revision of the Directive to address the information gap of owners and investors by providing documentation on the renovation roadmap of buildings.

4.2.3 Ensure that new buildings are in line with the 2050 climate neutrality objective.

This objective addresses the second key problem and the related problem drivers of the lack of standards and requirements for new and existing buildings in line with decarbonisation goals. For new buildings and for the transformation of existing buildings, a new vision going beyond nearly zero-energy buildings is needed. This will ensure that new builds are fully compatible with carbon neutrality goals and that lock-in to technologies with a long lifetime, which rely on fossil fuels for heating and cooling, is avoided. To achieve this objective, an update the current nearly zero-energy buildings requirements towards zero-emissions buildings requirements is necessary. The concept of zero-emissions buildings received support from 84% of the respondents to the public consultation.

For new buildings, this will mean designing building performance requirements that ensure much lower energy needs and phasing out fossil fuels for heating and cooling thanks to the deployment of renewables technologies. These include direct renewable-based electrification and modern low-temperature district heating and cooling that harness local renewable energy and waste heat resources. By addressing whole life

[74] 66 responses to the inception impact assessment encouraged the inclusion of building renovation passports in the revision of the EPBD. Most of these responses came from associations/business organisations as well as NGOs.

carbon and resilience[75], such a new vision would maximise decarbonisation and make new construction future-proof.

For this objective and the previous one there are synergies with the RED for heating and cooling target, the planned introduction of emissions trading for buildings, EED on heat planning and Ecodesign requirements and energy labelling of heating and cooling appliances.

4.2.4 Integrate buildings into decarbonised and digitalised energy systems.

This specific objective targets key enabling conditions to address the second key problem of putting building decarbonisation efforts on the right trajectory towards climate neutrality, as buildings today are not technically fit for the energy transition and for increased renewables deployment. However, this objective also addresses the first key problem and the need to step up energy renovations towards 2030, in particular with regard to the increased benchmarks for RES uptake in buildings as well as the benefits to energy performance through a deeper integration of buildings into a digitalised energy system.

The expected increase in the integration of renewable energy needed to achieve energy and climate goals and pave the way to carbon neutrality will require buildings fit for renewables with high thermal integrity and modern technical building systems. Given that part of the renewable energy will come from intermittent sources, buildings should also be able to provide flexibility and play an active part in the energy system by integrating storage and demand response/management services into the grid thanks to the smartness of their technical building systems. The more flexibility that buildings can offer to 'serve the energy infrastructure system' (mainly the power system) through storage, own power production and connected EVs, the more valuable they will be in the future energy system.

Under this objective, the EPBD revision aims to further modernise buildings and their systems (for heating, cooling, ventilation, renewables, flexibility and storage) across their whole lifetime, with digitalisation as the key enabler. In this regard, policy measures and options will explore the possibility to ensure building preparedness and to strengthen and improve the integration of the smart readiness indicator with new tools like digital logbooks and building renovation passports, in synergy with the forthcoming Digitalisation of Energy Action Plan[76].

---

[75] By taking into account in the design of the building the likely evolution of local climate conditions and their possible effects on energy performance and the building's physical integrity during the estimated lifetime of the building.

[76] Action plan on the digitalisation of the energy sector – roadmap launched | European Commission (europa.eu)

Another specific aspect to address under this objective is the problem of lack of charging points in residential and work parking spaces and administrative barriers for the owners of electric vehicles that need access to charging points. According to stakeholders, there is a need to strengthen the existing provisions on e-mobility, in particular for new buildings, and to introduce a 'right to plug' in multi-dwelling buildings. From this perspective, specific policy measures and options are proposed to ensure that new and existing buildings are being prepared for the introduction of e-vehicles and introduce the 'right to plug'. This will also complement the requirements on the deployment of publicly accessible infrastructure in the Alternative Fuels Infrastructure Regulation and is closely linked to the recast Renewable Energy Directive.

4.3 Intervention logic

The intervention logic to the EPBD revision is developed in Chapter 2 – Problem definition, Chapter 4 – Objectives, and Chapter 5 – Policy options. The three chapters are developed in a coherent and interlinked way feeding one into another – from the identification of key problems and problem drivers, general objectives and specific objectives, to policy areas of interventions and policy options. At the beginning of Annex E, the overall intervention logic, from problem drivers to policy options, is presented in a dedicated figure.

5. What are the available policy options?

5.1 What is the baseline from which options are assessed?

5.1.1 The baseline for assessment

All the 'Fit for 55' initiatives share a common baseline, the EU Reference Scenario 2020 (REF). It is the common starting point for energy system modelling in the respective impact assessments for all the proposals adopted in July 2021[77].

The EU Reference Scenario 2020 reflects current and planned policies, notably as stated in Member States' national energy and climate plans, and takes account of COVID-19 impacts. It models the policies already adopted, but not the target of net-zero emissions by 2050. As a result, there are no additional policies driving decarbonisation after 2030. The same baseline approach is followed in this impact assessment and the key parameters

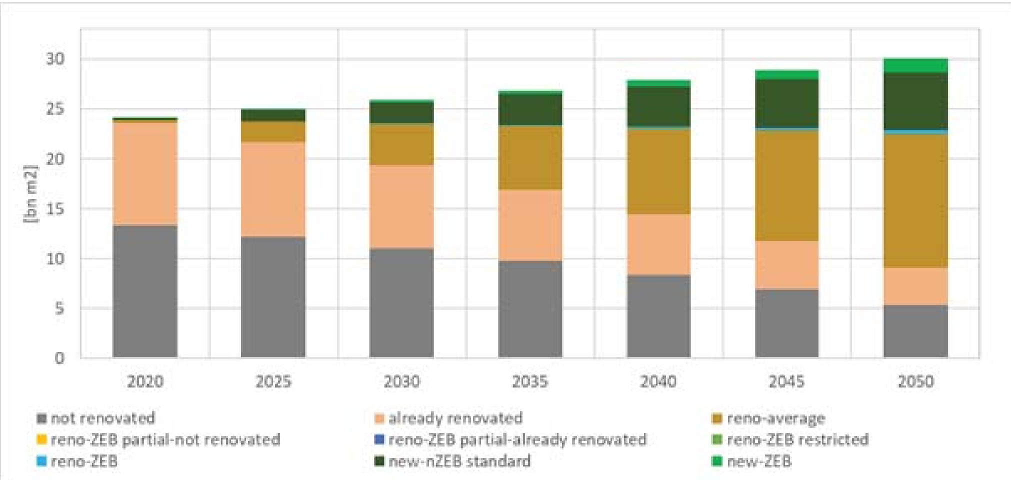
[77] Details can be found in the respective Impact Assessments, for example Annex D of the Impact Assessment Report Accompanying the document "Proposal for a Directive of the European Parliament and of the Council amending Directive 2012/27/EU on energy efficiency". Furthermore, a separate publication dedicated to the Reference scenario contains complete information about preparation process, assumptions and results: EU Reference Scenario 2020 | Energy (europa.eu).

used are aligned to REF. From a methodological point of view, this ensures coherence across the 'Fit for 55' initiatives[78].

The effects of the legislative proposal adopted by the Commission in the July 2021 'Fit for 55' package are therefore not included in the baseline for this impact assessment. The impacts of the revised EED, RED II, AFIR, ESR and of the introduction of a separate ETS on heating in buildings are assessed from the point of view of coherence and complementarity, in particularly in section 7.2.

In addition, the interplay between the 'Fit for 55' proposals is modelled by specific policy scenarios. This is done by the central policy scenario (MIX) and by a dedicated scenario (MIX-without-EPBD) which with a certain level of approximation disentangle the EPBD policy drivers (See section 6.2).

Figure 5.1: Floor area development in billion m², renovation and new construction levels, EU, Baseline Scenario (BSL)[79]



Source: Guidehouse et al.

The specific baseline used in this impact assessment focuses on the buildings stock only (and not to the overall energy system) and the impacts of the policy options are assessed

[78] Differently, the 'Gas decarbonisation package' which is also part of 'Fit for 55' follows a different approach and includes the expected impacts of the proposals adopted in July 2021 in the baseline of its impact assessment. For this reason, it adopts the MIX scenario as a starting point/baseline. The "Gas decarbonisation package" proposal focuses on policies related to infrastructure solutions, which are not dependent from the policy choices related to the policy mix driving energy demand for decarbonised fuels. In addition, the "Gas decarbonisation package" is not expected to have in itself impacts on the size of energy demand. The policy options under in the "Gas decarbonisation package" and their relations with the MIX and REF scenario are therefore fundamentally different from those in the EPBD revision.

[79] Source: Guidehouse et al. (2021). In this impact assessment, this reference identifies the following study, to be published: Technical assistance for policy development and implementation on buildings policy and renovation. Support for the ex-ante impact assessment and revision of Directive 2010/31/EU on energy performance of buildings Service request 2020/28 – ENER/CV/FV2020-608/07; DG Climate Action CLIMA.A4/FRA/2019/0011.

bottom-up. Given the long lifecycle of buildings, to illustrate the expected evolution of its energy performance and overall consumption, and the consequent CO_2 emissions, it is therefore important to look at the renovation of floor area over time. Figure 5.1 illustrates the expected renovation of the EU floor area (both residential and non-residential buildings) in the coming decades based on current policies and technology trends.

Approximately 80% of the 2050 building stock already exists today. Thanks to existing policies, technological drive and autonomous trends, the floor area renovated will slightly but progressively increase in the coming decades. It is estimated that more than half the existing building stock (13.3 billion m^2 out of a total of 24 billion m^2) has not been renovated since construction, while the remaining part has been renovated to a certain extent. The figure above shows that at current renovation levels the non-renovated share will progressively decrease. However, in 2050 about 40% of the stock will still remain in its original state, while in 2030 and 2050 respectively 17.6% and up to 60% of the stock will be subject to renovation to average levels, locking-in a significant amount of potential energy and emissions savings that could be achieved with higher rates of renovation.

The development of the EU floor area also illustrates that new construction more than compensate for demolition by 2050. In line with current renovation rates and trends, it also shows that most energy renovations are shallow (‘reno-average’) while deeper renovations (e.g. ‘reno-ZEB’) happen at a much lower rate. It is also assumed that until 2050 a small share of new buildings will go beyond the current NZEB standard[80]. Without accounting for new builds, in the baseline scenario the total final energy consumption of the building stock will decrease by 1.4%-1.7% every year[81] in the coming decades.

5.2 Description of the policy options

Based on existing studies, on the inputs from stakeholders and on internal analysis, a range of policy options and measures were screened to respond to the problems identified. The selection of options also builds on the analysis and stakeholder consultation made in preparation of the Renovation Wave strategy, which already identified key policy measures to be considered in the revision of the EPBD.

The measures identified were examined in detail and various options for their design were considered. Stakeholders were consulted specifically on each area and the available information was examined. The options are grouped into three areas (A, B, C)

[80] The energy performance associated to the different renovation types (e.g. ‘reno-average’, ‘reno-ZEB’) is described in Annex D.

[81] New buildings constructed between 2020 and 2050 are not included in this figure. Therefore, the total final energy consumption of the building stock would in reality be slightly higher.

responding to the specific objectives as described in Chapter 4 and addressing specific barriers identified in Chapter 2. The above figure visualises which are the policy measures contributing to each of the specific objectives identified.

Figure 5.2: Overview of objectives and policy options

Area A. Measures to increase the number of buildings being renovated and renovation depth.

Area A is at the core of the EPBD revision and contributes to the main objective of reducing buildings' greenhouse gas emissions and final energy consumption by 2030, to a level commensurate with the CTP goals. As regards the specific objectives of this initiative, the measures proposed in Area A aim at an increase of the number of buildings being renovated, especially those with a very low energy performance.

In relation to the problems identified in Chapter 2, area A addresses the first key-problem which is that the EPBD framework is insufficient to the achievement of the 2030 climate objectives and lacks measures to address the non-economic barriers limiting energy renovations. The underlying problem drivers are illustrated in the below table.

Table 5.1: Problems drivers addressed by the measures in Area A.

Problem drivers/barriers	MEP	BRPS	EPCQ	DEEP	LTRS

	S				
Split incentives	++				
Public financial support not sufficiently targeted toward deep renovations	+	+		++	+
Lack of information on energy performance of buildings and multiple benefits of energy renovations			+	+	
Lack of well-communicated decarbonisation trajectory	+				+
Lack of standardised information tools on energy performance			+		
Behavioural barriers	++	+	+		
Lack of standards and requirements for new and existing buildings in line with decarbonisation goal		+		+	
Insufficient measures to facilitate the integration of digitalisation and smart solutions in new construction and building renovations		+			
Insufficient measures to support the uptake of electromobility in private buildings					

This area addresses as well the second specific objective of the EPBD revision, which is to improve information on energy performance and sustainability of buildings with the use of digital tools. It contributes in particular to the improvement of the quality and comparability of information tools on energy performance of buildings across the EU. Respondents to the open public consultation have shown a key interest in strengthening some of the EPBD tools and provision under this policy area. In particular, 75% of respondents supported the introduction of minimum energy performance standards (MEPS) for buildings in the revision of the EPBD[82], 68% were in favour of the introduction of a legal definition of “deep renovation”, and 89% confirmed the need to strengthen the monitoring of the objectives identified in the Long-Term Renovation Strategies. Some stakeholders have spoken against the introduction of MEPS, arguing that their set up should be handled at Member State level. They also stated that Member States are still implementing the Clean Energy Package and that excessive regulation should be avoided. Rather, indicative guidance should be provided with technical and financial support. The large majority however expressed the need for a EU framework giving sufficient flexibility to Member States to adapt to local conditions. Few respondents indicate that the MEPS would not be necessary if the EU ETS is extended to the building sector. Few also consider that such minimum requirements will have a too strong impact on property rights that cannot be justified even in light of the need to act against climate change.

[82] The view of stakeholders on MEPS, collected in the different consultation activities supporting the EPBD revision is presented in Annex G.

The measures in area A are:

- *A.1 Minimum energy performance standards (MEPS): MEPS1, MEPS2, MEPS3, MEPS4*
- *A.2 Buildings renovation passport (BRP): BRP1, BRP2, BRP3*
- *A.3 Energy performance certificates (EPCs) – strengthening quality and comparability: EPCQ1, EPCQ2, EPCQ3*
- *A.4 Deep renovation standard: DEEP1, DEEP2*
- *A.5 Long Term Renovation Strategies (LTRS): LTRS1, LTRS2, LTRS3*

A.1 Minimum energy performance standards (MEPS)

MEPS are addressing the first key problem related to the non-economic barriers limiting energy renovations, in particular the split of incentives, the lack of a well-communicated decarbonisation trajectory and behavioural barriers leading to market failures. MEPS are policy instruments which require buildings to be renovated and improved to meet a specified energy performance standard at a chosen trigger point or date and can include standards that tighten over time. As such, MEPS drive an increase of rate of renovations which is necessary according to the analysis underpinning the CTP in order to reduce GHG in buildings by around 60% by 2030 as compared to 2015.

MEPS are already in use both in the EU and worldwide. The experiences from France, Belgium, Netherlands, Germany, Greece, England, Wales, and Scotland have been examined to identify the best policy design and success factors. Examples from regions where MEPS have been rolled out show that MEPS contribute to improved energy standards across the targeted stock and that high levels of compliance can be achieved if MEPS are accompanied by adequate enforcement framework and a policy-signalling effect on the markets. MEPS are also effective in addressing one of the most critical barriers to energy renovations, which is the split of incentives and benefits to renovations occurring for buildings which are rented and not owner-occupied. A detailed overview of MEPS applications is available in Annex F.

The set of options identified build on the success factors and lessons from the existing MEPS. The key criteria taken into account are also the consistency with the current EPBD architecture, to maximise the synergy with its existing tools to increase effectiveness, while respecting subsidiarity. As regards subsidiarity, the options identified distinguish between MEPS based on a common EU framework, MEPS based on national plans and voluntary MEPS.

Several designs are possible, as illustrated by the varied experiences worldwide. The modulation of options has been made on the basis of the following three key design features: (a) identification of targeted buildings, (b) metric of the energy performance standard, and (c) trigger point for the implementation of MEPS. Each design feature can be modulated in a way to match increasing ambition levels.

By combining the above design criteria and features, the following specific options were identified. In **MEPS1** the standards are established at EU level but they will only cover limited amount of buildings, to ensure minimum common efforts. The trigger point is the moment of transaction of the buildings (rented or sold). Buildings will be bought or rented only under the condition to achieve an energy performance at a level at least equivalent to a certain EPC class, or subject to an upgrade of their energy performance within a certain time span. The minimum EPC class (expressed as primary energy demand and measured in kWh/(m^2·y)) to be applied for buildings transactions will be progressively increased, for instance from class E in 2027 to Class D in 2030 and Class C in 2033, following a trajectory compatible to the long-term goal of decarbonisation of the building stock. This option can be implemented by specific requirements in the EPBD, to be based on national EPC schemes which are already in place in all MSs but which would have to be updated to ensure that similar efforts are made across the EU, while taking into account national and regional specificities. While specific compliance measures will be necessary, enforcement will be supported and facilitated by the provisions already existing in the current EPBD, as EPCs are already required for every building transaction. MEPS1 should also include specific exemptions for buildings for which energy renovations are subject to certain technical constraints. As the targeted buildings under MEPS1 will only cover a limited fraction of the EU building stock, MSs could decide to apply MEPS to the rest of the building stock, on a voluntary basis.

Under options **MEPS2** and **MEPS3** MSs are allowed more flexibility in setting minimum energy performance standards in comparison to MEPS1, both as regards the trigger points and the type of buildings or building segment to be affected. In MEPS2 and MEPS3 there are no measures established at EU level, and MEPS are instead to be established at national level. The national MEPS schemes will have to follow a trajectory in line with the transformation of the national building stock into zero-emission buildings by 2050. Flexibility will be left to Member States to set locally relevant standards and to best adapt MEPS to national or local specificities in terms of buildings ages, specific ownership structure and climatic conditions. MEPS will have to be designed based on the national milestones and goals set by MSs in their LTRS, and contribute to their achievement. Specific national criteria could be set up also to allow that MEPS are framed to address indoor air quality concerns, so to target the buildings types with poor energy performance, which affects the health and well-being of people. MEPS2 and MEPS3 differ for the targeted buildings, as in MEPS3 only non-residential buildings will be affected (public buildings, offices, hotels, etc.), while under MEPS2 standards apply progressively to the entire building stock. MEPS will have to be designed to complement (where existing) the national schemes providing incentives to renovation such as tax exemptions or fiscal and financial measures. Additional provisions which could support national MEPS relate to addressing the barriers to renovation in multi-family buildings, for example by removing unanimity requirements in co-ownership structures, or allowing co-ownership structures to be direct recipients of financial support.

Differently from the other options which foresee that the metric for MEPS is the overall building energy performance based on the EPC class, **MEPS4** has a narrower scope as it is based instead on the performance of the heating and cooling appliances installed in the building or building unit. 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 based on carbon emission performance levels. This option can be implemented by specific requirements in the EPBD, building on the existing provisions on technical building systems under Article 8. Compliance can be ensured via the inspections mechanisms already foreseen. Generally, the replacement of the heating and/or cooling appliances alone without a combination of improvements to the thermal integrity of the building can lead to suboptimal results and lock-in effect that cannot guarantee that a building is renovated over time in a way to become '2050 ready'. To avoid lock-ins and suboptimal choices resulting from the implementation of this option, the planning of a staged renovation with the support of a building renovation passport could be envisaged.

The options identified are not alternative to each other but can be combined to increase impacts and effectiveness. The advantages of combining options are discussed in Chapter 6.1. Aspects of technical feasibility and exemptions to be applied are to be provided for each of the options, and can build on the exclusions already identified in the EPBD for the implementation of minimum energy performance requirements[83]. Specific measures and a more targeted set of accompanying measures, could also be established for multi-ownership and multi-apartment buildings.

All options will only be acceptable and successful if specific financial instruments (such as energy efficiency mortgages) and funding schemes are made available to support the affected building owners (in particular low-income households), which would face increased investments costs upfront, while the reward in terms of lower energy bills and other benefits will be spread along a longer period[84]. This aspect has been clearly underlined by stakeholders, which indicated that targeted financial support for low to middle-incomes households coupled with minimum energy performance standards are the main areas where to focus to address energy poverty. In connection with MEPS, some stakeholders also highlighted the need to respect cultural heritage in buildings as part of the cultural heritage of the EU and the higher costs of their renovation.

A.2 Buildings renovation passport (BRP)

BRPs are stepwise roadmaps with renovation measures tailored to individual buildings, typically with a 15-20-year timeline[85]. BRPs are being implemented already in some

[83] In article 4(2) of the EPBD, specific exemptions to the application of minimum energy performance requirements are foreseen.
[84] Bertoldi, P, Economidou, M, Palermo, V, Boza-Kiss, B, Todeschi, V. How to finance energy renovation of residential buildings: Review of current and emerging financing instruments in the EU. WIREs Energy Environ. 2021; 10:e384. https://doi.org/10.1002/wene.384
[85] BPIE (2018).

countries or regions[86] and are already mentioned as optional tools in Article 2a(1)(c) of the EPBD.

Achieving a successful deep renovation requires expertise and careful detailing of the renovation measures, especially when it is achieved in several stages. The BRP can facilitate this by providing a tailored renovation roadmap for a specific building, which can be carried out in one stage or multiple steps over several years, thus helping owners and investors to better align renovation according to, on one hand, short-term individual needs and financial availability and, on other hand, long-term requirements[87]. The majority of the respondents to the public consultation recognised the need to establish this new tool, and to favour its development through guidance, best practices exchanges and funding to develop the appropriate framework.

The feasibility study on the possible introduction of a European BRPs pursuant to Article 19a EPBD concluded that 'existing Building Renovation Passports have proven that the instrument is effective in providing renovation advice taking into account the long-term vision for the building stock. It influences the renovation rate (number of energy renovations), renovation depth (scope of the renovation and energy savings to be achieved), the timing of the works (building owners with a BRP tend to renovate earlier than they previously planned) and the quality of the works (fewer mistakes and unwise renovation decisions)[88].

On the basis of the lessons learnt from existing experiences, and of the preferences expressed by stakeholders, the following three options have been identified. **BRP1** reflects the possibility to introduce a voluntary framework for BRPs in the EPBD, to be implemented in subsequent steps, mirroring the gradual process involving industry and other stakeholders which has led to the development of the Smart Readiness indicator. Under BRP1 the national implementation of BRP is voluntary, interested actors develop their BRP product autonomously on the basis of the common EU framework, and its deployment is led by market conditions. In **BRP2** MSs are required to set up a national common framework for BRPs, which nonetheless remains an optional tool. The use of the BRP becomes mandatory for financial incentives for staged deep renovations in **BRP3**, which is the most ambitious option.

The building renovation passport will be digital, issued by a qualified and accredited expert, following an on-site visit. It will comprise a renovation roadmap indicating a sequence of renovation steps building upon each other, with the objective to transform

[86] Known implemented BRPs are the Flemish Energy Performance Certificate [Belgium], the local Energy House Passport [France] and private Energy Efficiency Passport [France], the Individual Renovation Plan [Germany], as well as pilots tested in the iBRoad project (with pilots in Poland, Portugal, Germany, Bulgaria and stakeholder engagement in Greece, Romania and Austria). Ireland is piloting a building renovation passport, based on the iBRoad model.

[87] Fabbri, M et al. (2020). "Final report – Technical study on the possible introduction of optional building renovation passports". European Commission. (Available: Online)

[88] Ibidem.

the building into a zero-emission building by 2050 at the latest. It will have to indicate the expected benefits in terms of energy savings, the impact on energy bills and greenhouse emission reductions as well as wider benefits related to health and comfort. It will contain information about potential financial and technical support. The requirement to have a BRP on the basis of which to renovate buildings can either apply to specific building types, or to trigger points, like for instance becoming a pre-condition to access certain funding instruments.

Independent control systems for the building renovation passports will have to be established, and the EPC should indicate if a building renovation passport is available for the building.

A.3 Energy performance certificates (EPCs) – strengthening quality and comparability

Energy performance certificates (EPCs) are a well-established instrument under the EPBD[89]. Their purpose is to provide information on a building's energy performance status and to offer suggestions for cost-effective improvements. On an aggregate level, they offer information about the performance of the building stock.

The strengthening of the EPC framework in the EPBD revision pursues different goals, and options linked to these goals are therefore presented separately in this impact assessment. Under *Area A* the options to improve **quality and reliability** are presented, as those are considered to be instrumental to support and facilitate a successful roll-out of MEPS.

Options **EPCQ1** and **EPCQ2** foresee the introduction in the EPBD of a common and digital template for EPCs (voluntary or mandatory). The standardisation of EPCs will facilitate its acceptability and recognition by users, and the harmonisation of this tool could also be deepened to its content and to the calculations to be applied while compiling EPCs. Options **EPCQ1** and **EPCQ2** differ from **EPCQ3** as regards the modality to pursue the goal of establishing more homogeneous rating of buildings across countries. While in **EPCQ1** and **EPCQ2** benchmarks to facilitate the harmonisation of energy performance classes across MSs remain voluntary, in the most ambitious option **EPCQ3** MSs are required to harmonize to a greater degree, by establishing the highest and lowest classes of energy performance and ensuring an even distribution of energy performance indicators among the classes. The EPC 'class A' will correspond to zero-emission buildings and the letter G will correspond to a certain percentage of the worst-performing buildings in the national building stock. Other important routes to ensure that EPCs become more reliable relate to the conditions under which EPCs are issued and to the ex-post quality controls in place. Those are made more stringent in option **EPCQ3**. Reporting measures could enhance the transparency, credibility and reliability attributed

[89] See Annex G for an overview of the current implementation of EPC across Europe.

to EPCs, by requiring that certain information is regularly disclosed to the general public (in respect of GDPR rules) and to the European Commission.

According to the public consultation, 65% of respondents consider that EPCs need to be updated and their quality needs to be improved. The suggested areas for improvement include requiring on-site visits, use of metered data, improved quality control schemes and training of experts. The value of site visits is recognised in inspection schemes, such as the inspection schemes in-line with Articles 14 and 15 of the EPBD. This is due mainly to the feasibility to produce more detailed and better tailored recommendations which fit to the actual situation in the building. Site-visits and inspections also allow the evaluation of elements such as the state of the installations, indoor air quality or indoor environmental quality. These elements are otherwise difficult to evaluate through indirect means, unless it is through more developed monitoring systems, such as those found in Building Automation and Control Systems. Finally, the direct contact with the expert is also valued as it increases the perception of quality and reliability. A better integration between EPCs and inspection would provide additional benefits.

76% of respondents think that harmonisation of EPCs is needed to accelerate the increase of building performance: 46% indicate that this can be achieved by introducing a common template, while 15% think that harmonisation is not needed. In particular, stakeholders suggest that harmonisation of EPCs is needed in terms of calculation methodology, scope, quality and availability of information and implementation process, while ensuring sufficient flexibility to cater for each Member State's specificities, to adapt to local circumstances, to ensure reliability and allow for MSs to be more ambitious.

In the open public consultation, stakeholders have also pointed out the very relevant role of EPCs in linking targeted financing to deeper renovations, by underlining that EPCs are the key tool to assess energy efficiency improvements for financing purposes.

A.4 Deep renovation standard

As stated in the Renovation Wave strategy, the introduction of a 'deep renovation' standard will "enable anchoring significant private and public financing to transparent, measurable and genuinely "green" investments". Such a standard, or definition, can help creating an enabling framework for deep renovations that are currently not cost-effective from a purely financial perspective, by providing clarity to investors and authorities in charge of designing incentives and funding schemes about the type of interventions that can be qualified as deep. The Taxonomy delegated act has defined requirements for building renovation and individual renovation measures to be considered sustainable[90]; investors may decide to tie financial support for building renovation to Taxonomy

[90] A building renovation is taxonomy-compliant if it leads to 30% energy savings or complies with minimum energy performance requirements.

compliance. A deep renovation standard could go beyond the Taxonomy requirements and set a “gold standard” for building renovation that is fully compliant with the path to zero-emission buildings; compliance with the deep renovation standard could give access to additional financing beyond standard financial support.

Today, “deep renovation” is commonly understood as achieving 60% energy savings[91], disregarding the starting point of the renovation and the standard to be reached. With a view to the need for all buildings to be fully decarbonised by 2050 at the latest, the new deep renovation standard will set the attainment of the new zero-emissions building standard (see chapter 5, section B.1) as the goal to be achieved, however not counting shallow renovations leading to this result.

Deep renovation is not always achievable in one go, due to high upfront costs and the extent of the required works; however, a first step of a staged renovation is a better measure towards decarbonisation of a building than a complete renovation to lower standards[92]. The deep renovation standard should therefore also define “staged deep renovation”, for example as a series of renovation measures set out in the Building Renovation Passport which achieve the zero-emission building standard over a certain number of years. Option **DEEP1** provides for the introduction in the EPBD of a standard for deep renovation, including staged deep renovation, which transforms a building into a zero-emission building. In **DEEP2**, Member States are required to provide a higher level of financial support for building renovation which complies with the deep renovation standard than for building renovation which does not.

The 68% of the respondents to the public consultation identified the need to develop a legal definition for “deep renovation” that takes into account wider environmental, social and health aspects, by including embodied GHG emissions, as well as accessibility, air quality and climate resilience considerations. A few of the stakeholders expressed the need to see the seismic risk taken into account in the regions around the Mediterranean.

A.5 LTRS – Long Term Renovation Strategies

Under the EPBD (Article 2a), all EU countries are required to submit to the Commission a Long-Term Renovation Strategy (LTRS) outlining clear plans to support the renovation of their national building stock into a highly energy-efficient and decarbonised building stock by 2050. The framework for the establishment of long-term buildings renovation strategies in the EPBD was put in place before the commitment to carbon neutrality by 2050 and to the reduction of GHG by 55% by 2030. Therefore, to be aligned with higher climate ambition, to support the need to increase the rate of renovations, under **LTRS1** the cycle to prepare LTRS is shortened to 5 years, and in addition to that in **LTRS2** a

[91] See 2019 Commission Recommendation on Building Renovation (EU) 2019/786.

[92] For example, the thick insulation of one façade, to be followed by similarly thick insulations of other façades, is a more desirable renovation than a thinner, simultaneous insulation of all façades which precludes additional insulation layers in the future.

specific monitoring and reporting framework is established, taking advantage of what is already in place for NECPs under the Governance Regulation. In **LTRS3** the requirements are enlarged, including the reporting of the deployment of renewable energies in buildings and operational greenhouse gas emissions and goals. Carbon metrics, covering the whole life cycle of buildings[93] are necessary for achieving zero-emission buildings and climate goals, in addition to operational energy performance metrics and the LTRS shall include an overview of policies and measures for the reduction of whole life-cycle greenhouse gas emissions in the construction, renovation, operation and end of life of buildings. The LTRS would then evolve into a more operational plan, to be renamed “Building Renovation Plan”, which shall include a detailed overview of national building sectors, establishment of specific targets, presentation of existing and planned measures to achieve the targets and specific monitoring and reporting framework on the cost-effective use of Union and national financings, leverage of private financing and use of financial instruments, in order to better direct and align spending to achieve the long-term goals set out[94].

The policy options for LTRS are in line with the findings of the open public consultations, where 61% of the respondents identified the need to amend the existing provisions in the EPBD on lTRS. In particular, 89% of the overall respondents underlined that the European Commission should strengthen the monitoring mechanism of the objectives identified by the Member States in their LTRS. The majority of the respondents in this regards pointed to the development of a common template with a monitoring framework requesting specific data and indicators.

Area B. Measures to enable the decarbonisation of new and existing buildings

This area of action is mainly targeting the second key problem identified that the EPBD framework is insufficient for the 2050 climate objectives and to foster energy system integration. The policy options therefore address the underlying problem driver of a lack of standards and requirements for new and existing buildings in line with decarbonisation goals. In addition, the policy options are aimed at providing a long-term vision for buildings in line with climate neutrality in 2050. The measures in Area B also address the need to improve information on energy performance and sustainability of buildings with the use of digital tools.

The options have been developed to upgrade the existing EPBD tools in line with increased climate ambition, so to ensure that existing standards and information tools would provide clear information about the carbon emission performance of the building and adequately inform the public about the measures to decarbonise them. The following table illustrates the main problem drivers addressed by the policy measures in this area.

[93] From production and transport of materials, the construction, to the demolition/reuse.
[94] This is in line with specific recommendations from the European Court of Auditors, Special Report 2020 “Energy efficiency in buildings: greater focus on cost-effectiveness still needed”, https://www.eca.europa.eu/Lists/ECADocuments/SR20_11/SR_Energy_efficiency_in_buildings_EN.pdf .

Table 5.2: Problems' drivers addressed by the measures in Area B.

Problem drivers/barriers	**ZEB**	**EPCI**
Split incentives		
Public financial support not sufficiently targeted toward deep renovations		+
Lack of information on energy performance of buildings and multiple benefits of energy renovations		+
Lack of well-communicated decarbonisation trajectory	+	
Lack of standardised information tools on energy performance		+
Behavioural barrier	+	
Lack of standards and requirements for new and existing buildings in line with decarbonisation goal	++	
Insufficient measures to facilitate the integration of digitalisation and smart solutions in new construction and building renovations	+	+
Insufficient measures to support the uptake of electro mobility in private buildings		

As indicated by stakeholders and in line with the energy efficiency first principle, while an operational carbon metric should become integral part of the EPBD, it should not prevail but rather be considered a complementary one going hand in hand with indicators for energy efficiency and integration of renewable energies. In addition to reducing operational carbon, there is also a need to address carbon emissions over the full life-cycle of a building which is why a calculation and disclosure of life cycle carbon emissions is proposed in some of the options for new construction, with a link to the EPC of the building.

As regards standards for new buildings, Article 9 of the EPBD states that Member States shall ensure that new buildings occupied and owned by public authorities are NZEBs[95] (Nearly Zero-Energy Buildings) after 31 December 2018 and that all new buildings are NZEBs after 31 December 2020. The EU legislative framework for buildings requires EU Member States to adopt their detailed national application of the EPBD definition on

[95] In accordance with the EPBD, a NZEB is a building that "has a very high energy performance with the nearly zero or very low amount of energy required covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby". The first part of this framework definition establishes energy performance as the defining element that makes a building an 'NZEB'. This energy performance has to be very high and determined in accordance with Annex I of the Directive. The second part of the definition provides guiding principles to achieve this very high energy performance by covering the resulting low amount of energy to a very significant extent by energy from renewable sources.

NZEB[96], supported by national policies for their implementation, which has led to the integration of the NZEB concept into national building codes and international standards. The legislative framework for NZEB was established in 2010, and the current NZEB definition does not ensure that buildings constructed today are '2050 ready', and that they could benefit from the already existing cost-efficient technologies that enable buildings to be zero-emission. While the implementation of NZEBs from 2021 (and 2019 for public buildings) onwards represented one big opportunity to increase energy savings and minimise greenhouse gas emissions, such definition is not anymore aligned with increased climate ambition. A more modern vision for new and deeply renovated buildings will have to include aspects related to green-house gas emissions related to the energy system services such as RES production, flexibility and storage and whole life carbon. In addition, other aspects could be addressed by Member States, such as climate resilience, seismic safety, fire safety and aspects of indoor air quality for new and renovated buildings. On the latter, several stakeholders called for higher ambition for health protection in buildings.

Another important set of measures relate to the introduction of a mandatory carbon metric for operational carbon in EPCs, as although some MSs have already implemented it[97], this is currently not a required element for EPCs. A visible indication of carbon emissions would raise awareness, create a positive dynamic in the markets of construction and renovations across its value chains, and drive informed decisions by all operators involved in the purchase or renting properties. In the options corresponding to higher ambition, the EPC will include a mandatory operational carbon metric, and if a calculation of whole life carbon has been made for the building it will also be mandatory to include it in the EPC.

<u>The measures in Area B are:</u>

- *B.1 Introduction of a definition of "zero-emission buildings"(ZEB): ZEB1, ZEB2, ZEB3*
- *B.2 EPCs - Increase the scope of information and coverage of EPC:EPCSI1, EPCSI2, EPCSI3*

B.1 Introduction of a definition of "zero-emission building".

The concept of (net) zero greenhouse gas (GHG)/carbon emission(s) buildings is gaining wide international attention and is considered to be the main pathway for achieving climate neutrality targets in the built environment. A 'zero-emission building' standard should ultimately aim at maximising the efficient and smart use of energy, materials and space. Different terms and definitions can however be used, therefore the first step which

---

[96] The implementation of NZEBs is connected to the assessment of cost optimality and high performance technical solutions in buildings.
[97] 16 MS have already introduced carbon metrics in EPCs (mostly voluntary).

has been considered is the establishment of a sound technical qualitative definition to be introduced in the EPBD, to be applicable to new buildings and based on key criteria which contribute at the same time to achieve high energy efficiency, to limit or neutralise GHG emissions and to contribute to energy system integration (i.e addressing flexibility and storage which will be crucial for new constructions). These aspects have been examined in detail and the available approaches to define and operationalise the "zero emission" concept to buildings are presented in Annex H.

Among the available approaches, the following have been retained: A zero emission building shall be defined as a building that has a very high energy performance that complies with specific benchmarks. The very low amount of energy still required has to be fully covered by energy from renewable sources.

The approaches and timeline to its gradual phase-in have been examined and different options have been identified. **ZEB1**, **ZEB2** and **ZEB3** differ as regards the degree of harmonisation and level of flexibility in adapting the ZEB standard to national and local specific conditions. The scope of GHG emissions considered is also different, with ZEB1 and ZEB covering only operational carbon emissions while in ZEB3 also embodied emissions are considered.

While in **ZEB1** an approach similar to what the EPBD had established in 2010 for NZEBs is followed, in **ZEB2** numerical benchmarks or thresholds are established at EU level, thus guaranteeing a more standardised definition and easing compliance. In **ZEB3** the qualitative zero-emission definition includes further criteria introducing the consideration of whole life-cycle emissions. The aspiration is to introduce the consideration of whole life-cycle assessment of GHG emissions into building design and construction, by requiring their accounting and reporting for new buildings. This first step would increase awareness and the available data on whole life cycle emissions, provide an incentive to circular solutions and to the use of recycled materials, and pave the way for the development of further policies in the field.

B.2 EPCs - Increase the scope of information and coverage of EPC

Alongside the measures needed to improve quality and reliability of EPCs under Area A, here options to (i) enlarge the scope of the information to be presented in each certificate and (ii) to extend the overall use and coverage of EPCs are described.

Currently EPCs must be issued for all buildings or building units which are sold, or rented out to a new tenant. Public buildings above a certain size also need to display EPCs. According to the available data, only a limited share of buildings have an EPC. Most building owners and occupants are therefore not aware of the building's energy performance and of the measures which could be undertaken to improve it. To increase the number of buildings having an EPC, the options **EPCSI1-EPCSI3** foresee that additional buildings must have an EPC, with a varying degree of coverage for instance linked to specific trigger points (renewal of rental contracts, renovation[98], access to public fund, or replacement of a heating installation or another technical building system or building elements, e.g. windows). Another trigger to increase the information value of EPCs is to shorten its validity. The current validity period is considered by experts and stakeholders as too long, hampering the capability of EPCs to provide a valid and up-to-date representation/asset rating of the building performance.

Pursuant to Article 11 EPBD, the EPC must include the energy performance of a building (in kWh/m^2 year) and recommendations for improvement. The EPC may include additional indicators such as CO_2 emissions or the percentage of energy use from renewable sources, and such indicators are in fact already present in some national or regional schemes (see Annex G). To strengthen the information role of EPCs in driving decarbonisation, and its use in conjunction with other EPBD tools and measures, it is necessary that additional information is widely available to all EPC users. The options **EPCSI1** and **EPCSI2** address this aspect, and foresee that additional indicators are to be displayed in EPCs, with a varying degree of detail and flexibility. These options present a strong synergy with the suggested provision of a common EPC template. Key indicators to be included in EPCs relate to GHG emissions and the use of renewable energy, storage and flexibility capacity, e-charging points, the breakdown of different energy uses (e.g. heating, ventilation, lighting, etc.) or the type of systems installed and. EPCs could also indicate if a calculation of whole life-cycle greenhouse gas emissions has been made. Information in EPCs could expand also to cover technical details and information about the presence of indoor air quality sensors etc.

A key mandatory element of an EPC is the recommendations to improve the energy performance of the buildings. Stakeholders and experts indicated that this element has so far had limited value in absence of clearer fixed content. **EPCSI3** foresees that additional guidance or requirements are provided in the EPBD, allowing to quantify the estimated costs and energy savings which could be achieved by renovating the building or some of its elements, and linking those to the long-term goal of decarbonisation of the building stock. The recommendations in EPCs could also include specific assessment of the preparedness of the building technical system to the installation of highly efficient heating appliances, and could be substituted by a building renovation passport (BRP). EPC and inspections of heating and cooling systems can support the recommendations made by one another and allow for cross-checking of information and monitoring of results.

[98] Currently it is not mandatory to issue EPCs in conjunction to a major renovation. In some countries, especially in conjunction with the use of incentives schemes, it is foreseen to issue EPCs before and after the intervention, to demonstrate the impact of the energy renovation on the asset rating.

In the public consultation, stakeholders suggested to shorten the validity of the EPC and to increase the scope of information. It was also suggested that EPCs should be mandatory to access financial incentives for building renovation. As regards the scope of information in EPCs, 59% of stakeholders find it important or very important to increase the number of mandatory indicators in the EPC to include greenhouse gas emissions, generation of renewable energy, breakdown of different energy uses (i.e. heating, ventilation or lighting) or type of systems installed. Stakeholders also suggest to include information on demand-side flexibility, IEQ, EV recharging and storage among other additional indicators. As regards the recommendations, 68% of respondents suggest that the EPC should include further information on estimated costs, energy saving or cost savings, and 62% see a need for increased interoperability with other tools such as Building Renovation Passports, SRI and digital building logbooks. 55% of respondents suggest to tailor the recommendations towards deep renovations.

Area C. Measures to increase the modernisation and quality of buildings and of their systems, enabled by digitalisation of information tools

The options in Area C address the second key problem that the EPBD framework is insufficient for the 2050 climate objectives and to foster energy system integration. Area C relates specifically to the problem drivers of insufficient measures to facilitate the integration of digitalisation and smart solutions in new construction and building renovations and insufficient measures to support the uptake of e-mobility in private buildings. Therefore, options have been developed for stronger uptake of e-mobility and of smart solutions for energy management in buildings. The following table illustrates the main problem drivers addressed.

Table 5.3: Problems' drivers addressed by the measures in Area C.

Problem drivers/barriers	EM	EPCD	SRI
Split incentives	+		
Public financial support not sufficiently targeted toward deep renovations			
Lack of information on energy performance of buildings and multiple benefits of energy renovations		+	
Lack of well-communicated decarbonisation trajectory			
Lack of standardised information tools on energy performance		+	
Behavioural barriers	+		
Lack of standards and requirements for new and existing buildings in line with decarbonisation goal			+
Insufficient measures to facilitate the integration of digitalisation and smart solutions in new construction and building renovations	+		++
Insufficient measures to support the uptake of electro	++		+

mobility in private buildings			

The measures in Area C are:

- *C1. Measures to remove building-related barriers to e-mobility : EM-1, EM-2, EM-3*
- *C2. Enhance the role of EPCs as digital tools: EPCD1, EPCD2, EPCD3*
- *C3. Measures to support the implementation of SRI: SRI1, SRI2*

C1. Measures to remove building-related barriers to e-mobility

The analysis of pathways achieving a reduction of GHG by 55% in the CTP shows that electrification of transport is one of the most promising avenues for reducing the GHG emissions arising from individual mobility. The lack of easily available recharging points in private buildings can be a barrier when deciding whether to shift from a conventional car to an electric one. Providing for recharging infrastructure both in and close to buildings is therefore critical to enabling electrification of the transport sector[99].

The EPBD requires the installation of recharging points in certain parking spaces adjacent to residential and non-residential buildings and sets ducting requirements that allow for subsequent installation of recharging points in new or renovated residential buildings of a certain size (as well as for non-residential buildings), while the deployment of publicly accessible recharging points is addressed in AFID and reviewed in the AFIR proposal.

The requirements present in the EPBD since its revision in 2018 are however 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. 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, while **E-M3** extends the readiness also to the availability of parking space for bikes and strengthen the requirements for existing large non-residential buildings. To enhance the "right to plug", **E-M2** foresees that identified administrative barriers are removed and measures are undertaken to enhance the availability of technical assistance for households wishing to install recharging points. In line with AFIR and the revised RED it is proposed that recharging points shall be capable of smart charging and if positively assessed by the regulatory authority be capable of bidirectional charging.

According to the results of the public consultation, requirements for the installation of recharging points (65%), the right to plug (for both tenants and owners) (62%) and the inclusion of provisions for recharging points for vehicles other than cars (52%) are all

[99] Velten, E.K., Stoll, T., Meinecke, L. (2019). Measures for the promotion of electric vehicles. Ecologic Institute, Berlin. Commissioned by Greenpeace e.V.

necessary. 72% of respondents think that the installation of recharging points to support smart charging is needed.

C2. Enhance the role of EPC as digital tools

There is an increasing amount of data on building energy use and building occupants' energy consumption patterns. Collecting data and making them available in a transparent way would be useful for policymaking in buildings and social policy[100], and would support the creation of innovative energy and buildings services and the reduction of administrative burden relative to permitting and other regulatory procedures. To digitalise data collection about the building stock across Europe, the key challenge is to create a framework that systematises data collection, by allowing open interfaces and the integration of data from different sources and the automation of the process with minimal manual intervention. In addition, digitalisation of data collection should ensure compliance with data protection regulation and ensure digital security.

Data from EPCs can be combined with data from other sources, such as EPBD inspections schemes, administrative tools (e.g. building cadastre or building permits), observatories (e.g. on energy poverty) and information from research initiatives. Acces to building information is generaly very limited and could be improved.

To these ends, national databases of repositories of energy performance certificates are required in option **EPCD1**, with different criteria qualifying accessibility for users and reporting functionalities in its suboptions. Option **EPCD2** identifies key linkages to the EPC database to be allowed by national rules. Option **EPCD3** requires a mandatory national database, enhancing interoperability with other data sources and facilitating administrative compliance.

In the public consultation, stakeholders stressed the need for EPCs to be digital and the importance of EPC databases. 61% of respondents found it important or very important for MSs to develop an accessible EPC database with further information on the EPC, to include benchmarks and comparison tools to allow the comparison of similar buildings. Stakeholders also highlighted the importance of providing access to data as well as promoting data exchange and sharing.

C3. Measures to support the implementation of SRI

The ongoing voluntary application of the smart-readiness-indicator (SRI), based on the existing EPBD framework[101], is a chance to enable smart readiness of buildings and use efficient operation modes for individual buildings as well as the optimal system balance

[100] For instance for the monitoring of LTRS or MEPS implementation.

[101] https://ec.europa.eu/energy/sites/ener/files/smart_readiness_buildings_implementing_act_c2020_6929.pdf

between buildings and a renewable energy system and the transmission/distribution system[102].

To enlarge its application, the option **SRI1** foresees its integration with other information tools, while in **SRI2** its voluntary nature is revisited and SRI becomes mandatory for large non-residential buildings, in coherence with the current provisions of the EPBD on building automation and control systems. However, several stakeholders did not support that option, and suggested instead to focus on implementing SRI on a voluntary basis, and to develop links with other schemes.

5.3 Options discarded at an early stage

While the Inception Impact Assessment included the possibility to achieve the goals of the EPBD revision without regulatory measures, by means of reinforced non-regulatory policy instruments and additional guidance and support measures, such as technical assistance, information campaigns, training, project financing etc., this option was discarded at an early stage of preparation of this assessment. On the basis of the studies examining the problems underlying low renovation rates and their drivers, it was estimated that such an approach would be insufficient to remove the barriers preventing higher rates of energy renovations, or to provide trusted and comparable tools to investors. Stakeholders were also almost unanimous in recognizing the need for strengthened requirements to drive higher and deeper renovations, although not necessarily for all the supporting measures.

This is particularly the case for the development of minimum energy performance standards, and for the standards for new buildings, which requires to be enshrined in legislation to be effectively enforced. In the Renovation Wave strategy, the Commission already indicated that the strengthening of the regulatory framework would be essential to achieve the goals of doubling and deepening the rate of renovation of buildings, and indicated specific areas of reinforcement for the EPBD. Therefore, in the subsequent chapters, the package of measures included in the different options to be assessed include a mix of regulatory and non-regulatory measures[103] and no options features only non-regulatory measures.

Other measures which have not been assessed in detail include minimum energy performance standards based only on indoor air quality indicators. While such option was envisaged by some stakeholders and consideration on the indoor environment have become prominent during the COVID-19 pandemic, the appropriate indicators still have to be developed. In addition, while a very efficient house with poor air quality is not acceptable and both aspects can and normally are achieved in a complementary way,

[102] Verbeke, S.; Waide, P.; Bettgenhäuser, Kjell; Uslar, M.; Bogaert, S. (2018): Support for setting up a Smart Readiness Indicator for Buildings and related impact assessment. Final Report. vito, ECOFYS, Waide Strategic Efficiency, Offis.
[103] As for instance under BRP1 and EPCQ1.

higher environmental quality alone would not necessarily deliver also energy savings and the emissions abatement in the building sector, which is the primary aim of the EPBD revision.

The options to require that all buildings should have a BRP in place was also discarded as entailing excessive costs and BRP deliver benefits only in some circumstances.

Based on the CTP analysis and conclusions (MIX scenario, see also Annex J) and the Renovation Wave strategy, the options have been limited within the current boundaries of the EPBD.

Policy instruments and options outside the EPBD scope which could deliver higher renovation rates, e.g. through taxation or other fiscal measures, have not been assessed in preparation of this proposal. National tax-exemptions schemes and other forms of financial incentives through fiscal or non-fiscal measures, which are the competence of MSs, are fully complementary to the options proposed. Such incentives schemes will support the delivery of the ambition of the national renovation plans and will improve the affordability of the renovation investments which will be triggered and regulated via the EPBD.

6. What are the impacts of the policy options?

6.1 How the measures are grouped and assessed

The assessment of the impacts of the policy options considered for the revised EPBD starts with the aggregation of the measures and sub-options identified in Chapter 5, based on the following criteria:

- The strengthening of existing measures and the introduction of new ones to address the key problems underlying the revision of the EPBD follows the logic of identifying options of a variable level of policy intensity. The intensity has been regulated either on the basis of a progressive increase in the scope of their application – to a wider number of buildings or players – or of the stringency of the requirements proposed. For MEPS, this has been obtained by adding different MEPS mechanisms with distinctive trigger points and scope, covering a higher share of worst performing buildings and of the overall building stock. The four options are sufficiently varied in scope of application and intensity to allow for a good understanding of the different impacts that they could achieve on key performance indicators.

- The measures proposed for the revision support each other within the coherent and structured policy framework of the EPBD. Synergies exist across instruments in the different areas identified. For this reason, their effects and impacts are assessed jointly across the different areas and in groups of measures.

- Given the strong synergies and mutual support as indicated above, the impacts are associated across all areas, and the measures to which the majority of impacts are associated are highlighted in bold in Table 6.1.

On this basis, beyond the baseline, we have identified four different options for the EPBD revision packaging measures, characterised by progressively higher ambition levels (from low ambition to high ambition). Options 3 and 4 both show high ambition and differ only in the combination of MEPS sub-options. This chapter presents the main environmental, economic and social impacts expected from the above four options.

Table 6.1: Groups of measures across options

Areas	Baseline	Option 1. Low ambition	Option 2 Medium ambition	Option 3 High ambition I	Option 4 High ambition II
Area A. Measures to increase the number of buildings being renovated and renovation depth	EPC LTRS	**MEPS1** BRP1 EPCQ1 DEEP1 LTRS1	**MEPS1+ MEPS3** BRP2 EPCQ2 DEEP2 LTRS2	**MEPS1+ MEPS2** BRP3 EPCQ3 DEEP2 LTRS3	**MEPS1+ MEPS2+ MEPS4** BRP3 EPCQ3 DEEP2 LTRS3
Area B. Options to enable decarbonisation of new and existing buildings	NZEB EPC	**ZEB1** EPCSI1	**ZEB2** EPCS2	**ZEB3** EPCSI3	**ZEB3** EPCSI3
Area C. Measures to increase the modernisation and quality of buildings and of their systems, enabled by digitalisation of information tools	EM EPC SRI	**E-M1** EPCD1 SRI1	**E-M2** EPCD2 SRI1	**E-M3** EPCD3 SRI2	**E-M3** EPCD3 SRI2

Before presenting such results, it is important to explain how the effects of national schemes that set minimum energy performance standards (MEPS2, MEPS3) have been modelled[104]. This also brings with it policy considerations.

For MEPS2 and MEPS3, national MEPS schemes are modelled as standards that impose a progressive renovation pathway between 2025 and 2050. Through a combination of staged and single deep renovations, Member States gradually achieve higher shares of

[104] Annex F, Section 7.1 presents additional modelling choices.

buildings renovated to high standards, close to 'zero-energy building (ZEB) levels', thereby achieving decarbonisation of building stock by 2050. This is a simplification of the different choices that national authorities could make in implementing national MEPS alongside the trajectory and criteria established in the EPBD. Based on these choices, some building segments could be targeted as a matter of priority.

Importantly, the transformation modelled is required to achieve' a decarbonised building stock in the absence of other policies, which overestimates the regulatory effort and makes the decision to renovate more costly (in the absence of other incentives). In particular, in the context of the 'Fit for 55' package, this modelling mechanism does not take into account the effects of other EU instruments, which could also trigger decisions to renovate buildings or make the economic case for it more favourable. These instruments could be regulatory ones (like Article 6 of the Energy Efficiency Directive (EED) Recast or Article 23 of the Renewable Energy Directive on binding RES heating & cooling (H&C) targets) or market-based in the form of carbon pricing or enabling condition types (like Article 8 of the EED Recast, which makes funding more easily available). From a modelling perspective, this is a conservative approach as it is likely to overestimate the renovation efforts that would need to be triggered by MEPS2 and MEPS3 and the costs for consumers. From a policy perspective, this means that what is modelled by MEPS2 and MEPS3 is a **'maximum effect'.** In reality, the impact of MEPS (and corresponding effects in terms of benefits, costs and investments) could be lower as some renovation efforts would be incentivised by other policy instruments. These will be factored into the specific design of national MEPS mechanisms. Bearing this 'maximum effort' perspective in mind is crucial in designing the national mechanisms to introduce and enforce MEPS. These should be adaptable and coherent with other policies at EU and national level.

6.2 Impacts of the EPBD revision as part of scenarios delivering the increased climate target

In addition to assessing the impact of the EPBD revision alone, as explained in Section 6.1, we also need to see how they combine with the other 'Delivering European Green Deal' (DEGD) initiatives (also referred to as the 'Fit for 55' package) and what their cumulative impact is on the energy system and the economy as a whole. This exercise was performed with the 'core scenarios'[105] REG, MIX, MIX-CP, used in the impact

[105] See the description of core scenarios here: https://ec.europa.eu/energy/data-analysis/energy-modelling/policy-scenarios-delivering-european-green-deal_en as well as Annex 4 in the impact assessment accompanying the amendment to Renewable Energy Directive SWD(2021)621 final.

assessment underpinning initiatives tabled by the Commission in July 2021[106]. The EPBD revision with these scenarios is captured[107] by the following:

- an increased rate and depth of renovations (notably of deep and medium renovations instead of only light renovations)[108];
- an increased uptake of renewable H&C solutions (notably heat pumps) accompanying renovations – heat pumps become an attractive choice for low energy consumption of a deeply renovated building;
- more stringent and better enforced standards for new buildings[109];
- enabling conditions created by legal certainty on the measures described above and additional actions such as the building renovation passport to increase consumer awareness[110].

In fact, these elements were already part of the Climate Target Plan scenarios[111] that were later fine-tuned (as concerns both the baseline and preferred policy options) in the DEGD core scenarios.

The drivers described above – increased renovations also covering H&C equipment change and better performance of new buildings – can be found in the majority of decarbonisation pathways: in the Commission's own analysis (2050 Long-Term Strategy[112]), in Intergovernmental Panel on Climate Change work[113], or in stakeholders' own analysis such as 'Net Zero by 2050' from the International Energy Agency[114]. While the intensity of these drivers and their impact vary depending mainly on whether

[106] See the 'Delivering European Green Deal' website: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en

[107] Drivers capturing the EPBD revision are present in REG and MIX core scenarios, while the' MIX-CP scenario has those drivers increasing only slightly from the baseline level.

[108] Importantly, the renovations increase in MIX (compared to REF2020) is incentivised not only by drivers illustrating the revision of EPBD, but also the horizontal energy savings obligation (as in Article 8 of the proposal for a EED recast). Reflecting policy options described in Section 5, the whole increase of deep renovations (thanks to the introduction of deep renovation standards) and the partial increase of medium renovations (thanks to the introduction of MEPs and obligation to apply MEPs to buildings under transaction) is assigned to the EPBD revision. Removing these drivers would mean that some renovations do not happen and some are only light ones thanks to the operation of Article 8 of the proposal for a revised EED.

[109] Thanks to the introduction of long-term renovation strategies and the ZEB standard definition.

[110] In modelling terms, such enabling conditions translate into more frequent investment decisions as economic agents have full information about costs and benefits expected and in general perceive lower transactional costs.

[111] See impact assessment accompanying Climate Target Plan SWD(2020)176 final. All CTP scenarios except one (CPRICE scenario driven by carbon pricing) have drivers on building renovations and new building standards.

[112] In-depth analysis in support of Commission Communication COM(2018) 773.

[113] https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_Chapter2_Low_Res.pdf

[114] See: Net Zero by 2050 – A Roadmap for the Global Energy Sector, https://www.iea.org/reports/net-zero-by-2050

scenarios are constructed top-down (target-driven) or bottom-up (measures-driven), they are, in most of the scenarios, part of the toolbox and have a visible impact on reducing energy demand in the building sector and on the fuel switch. The exceptions are carbon pricing-driven scenarios. These usually show that even high levels of carbon pricing do not properly incentivise renovations of building shells in particular (due to the multiple and non-economic barriers explained in Chapter 2). They therefore require an even more significant fuel switch. This results in a lower energy renovation rate overall (see Figure 6.12 below, with the MIX CP scenario representing the scenario with greater reliance on carbon pricing) or scenarios that by design concentrate only on the fuel switch, neglecting energy efficiency and therefore have the shortcoming of showing very high demand in low-carbon energies[115]. A case in point is the 'delayed retrofit case' of the International Energy Agency[116].

Among DEGD scenarios, the central MIX scenario has ambitious drivers that effectively represent the preferred options for the revision of EPBD working in synergy with carbon pricing. On the REG scenario, it shows a further increased regulatory effort, with correspondingly higher investment expenses, also required by lower income households. Conversely, the MIX-CP scenario shows a very high carbon price (EUR 80/tCO2 in 2030 in the building and transport sectors with only a lower intensification of regulatory measures) that would translate into high energy prices for all consumers (thereby having a regressive effect if not mitigated by revenue use). The MIX-CP scenario illustrates very well that carbon pricing alone, even at higher levels, does a poor job of incentivising renovations of buildings to optimal levels (in particular their thermal envelope), as it alone cannot tackle market and non-market barriers described in the problem definition of this initiative (Figure 6.1). The economic incentives of carbon pricing and revenues raised can be used for other measures to tackle those barriers more effectively and address social impacts of carbon pricing[117].

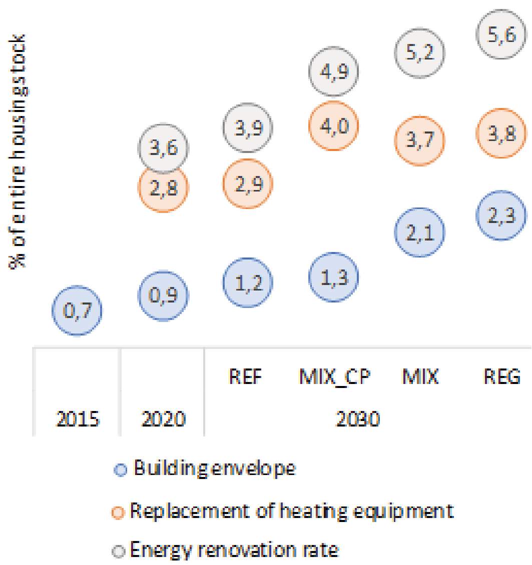
The common analysis produced for the 'Fit for 55' package provides elements that illustrate the interactions between regulatory measures targeting energy consumption in

[115] This is the case of some scenarios advocating a 100% renewables-based energy system and usually showing high demand in biomass or land (for wind or/and solar power).
[116] This scenario shows that (on the global level) a delay in reaching 2.5% of annual renovations by 2030 would require a very steep increase of renovations post-2030 (in order to reach carbon neutrality) and, even if we catch up, would cause an increase in residential space heating energy demand of 25% by 2050, in space cooling of more than 20%. This translates to a 20% increase in electricity demand, putting strain on the power sector, which would need much more low-carbon generation capacity. See: Net Zero by 2050 – A Roadmap for the Global Energy Sector, https://www.iea.org/reports/net-zero-by-2050
[117] See Chapter 2.2. As explained in DEGD initiatives, the low ambition policy options consisting of additional guidance only for energy efficiency or renewables polices would likely lead to results of the MIX-CP scenario. Conversely, the most ambitious regulatory options would yield results similar to the REG scenario with low/irrelevant carbon price applied in sectors beyond the current ETS. Moreover, the low ambition outcome of the legislative processes or delays in implementation – be it on regulations or on carbon pricing – would be illustrated by the MIX-CP or REG scenarios respectively.

buildings, in particular the EPBD and the proposal for a new emissions trading system (ETS) to abate greenhouse gas (GHG) emissions in this sector as well as the contribution of decarbonisation of buildings to the EU GHG target.

Among the three core policy scenarios[118] produced in the context of the 'Fit for 55' package, the MIX-CP scenario describes a policy environment where the drivers for energy efficiency and renewable energy uptake in buildings are closer to the existing energy policy framework (represented by the 2020 Reference scenario). In particular, it achieves lower renovation rates of buildings' thermal envelopes, close to Reference. Likewise, it has low drivers for renewables uptake in H&C, close to reference levels, but significantly incentivises the uptake of renewable energy in heating and cooling, including of heat pumps in buildings via carbon pricing. This scenario falls short of the proposed new 2030 targets related to energy efficiency and renewable energy. However, the MIX-CP scenario achieves the 55% net GHG emissions 2030 target.

Figure 6.1: Renovation rates in the Delivering the European Green Deal scenarios



Source: Primes

[118] The 'Fit for 55' three core policy scenarios, including the MIX-CP scenario, are described in 'Annex E Analytical methods' of the impact assessment (SWD(2021) 623 final) accompanying the proposal for a revision of the Energy Efficiency Directive (COM(2021) 558 final), as well as in 'Annex 4: Analytical methods' of the impact assessment (SWD(2021) 621 final) accompanying the proposal for a revised Renewable Energy Directive (COM(2021) 557 final). Detailed results can be found at: https://ec.europa.eu/energy/data-analysis/energy-modelling/policy-scenarios-delivering-european-green-deal_en

The lower ambition energy policy framework entails on the one hand a higher carbon price in the 'new ETS' sectors than in the MIX scenario[119] (EUR_{2015} 80/ t CO2 in MIX-CP, against EUR_{2015} 48/ t CO2 in MIX[120]) and, on the other hand, a lower contribution of buildings to GHG emissions reductions[121]. The lower CO_2 reductions in buildings is to be compensated, in the MIX-CP scenario, by higher reductions of CO_2 emissions in the power system and non-CO_2 emissions compared to the MIX scenario.

The MIX-CP scenario therefore illustrates the importance of having a policy framework that can trigger a reduction in energy consumption and shift towards low carbon fuels in buildings. This is the aim of a proposal for a revision of the EPBD, to complement the proposal for a new ETS that covers emissions from buildings and road transport.

The central MIX scenario illustrates that ambitious renovations and investors' certainty created by it are part of the well-balanced policy mix towards the GHG target of 55% and, in the longer term, climate neutrality. But the MIX scenario on its own cannot answer the question of how much of GHG reductions, energy savings, renewables deployment or cost increases can be attributed to drivers that illustrate the revision of the EPBD.

For this purpose, a counterfactual MIXwoEPBD scenario variant was developed that removes the main policy drivers that represent the EPBD revision, but keeps other MIX drivers (notably carbon price to the same level) frozen at the levels present in the MIX scenario (see Annex D for a description of the scenario). Using this design, the MIXwoEPBD variant complements MIX-CP, which similarly had few EPBD revision relevant drivers, but compensated for this with increased carbon pricing.

As a result, gaps to the energy targets appear in the MIXwoEPBD variant, which also results in fewer contributions to GHG reductions. These gaps are substantial, and bridging them can be attributed to the EPBD revision. This approach therefore provides the necessary insights to see the value added of the EPBD within the complete set of DEGD proposals. It does have weaknesses: it is a static counterfactual (the real-life carbon price would have increased as already illustrated in the MIX-CP scenario). It captures only implicitly the more granular impacts of EPBD revision such as building passports, long-term strategies or actions in the area of modernisation and quality of buildings and of their systems. These are enabled by the digitalisation of information tools and the impacts of the EPBD revision on e-mobility deployment, which to some

[119] The MIX scenario includes a balanced approach between price-based mechanisms (like the ETS) and sectoral regulatory instruments.
[120] See Table 15 of the impact assessment (SWD(2021) 623 final) accompanying the proposal for a revision of the Energy Efficiency Directive.
[121] See Table 15 of the impact assessment (SWD(2021) 623 final) accompanying the proposal for a revision of the Energy Efficiency Directive.

extent may also be captured by other policies, including the market signalling function of the carbon price effect. The quantitative assessment of the impacts of the specific policy options proposed is mainly performed using a building stock model and assessing the effect of the measures proposed bottom-up.

Bearing in mind these limitations, the variant still provides a useful assessment that is reflected in the sections below. It does so by complementing the main analysis, which compares the EPBD revision alone to the baseline with the analysis of gaps created by the MIXwoEPBD variant. The following sections provide a summary of the MIXwoEPBD variant, while Annex D contains a more detailed description.

Results of MIXwoEPBD variant analysis

By removing the drivers illustrating the EPBD revision, a gap is created between the variant and the MIX scenario. Bridging the gap can be attributed to the revision of the EPBD. We can therefore identify the absolute impact in terms of bridging the gap with the GHG target of 55%, the newly proposed energy efficiency target[122] and renewable energy targets[123] (e.g. in amounts of CO_2 saved, energy saved, renewables uptake or costs/investment increase). In addition, these absolute amounts due to EPBD revision can be compared to the full gap between the REF2020 and MIX scenario to be bridged by all DEGD measures, thereby providing information in terms of relative impact or required impacts by other policy drivers[124]. The following impacts can therefore be identified from the below analysis of the MIXwoEPBD variant. Table 6.2 presents a summary of key results.

Energy system impacts

The MIXwoEPBD variant creates a significant gap to the necessary 2030 energy efficiency in final energy consumption. Bridging this gap corresponds to 24% of the total, economy-wide final energy savings effort between the REF2020 and MIX scenario. The savings in final energy consumption have effects on primary energy consumption. A gap to the necessary 2030 energy efficiency in primary energy consumption therefore

[122] The newly proposed energy efficiency targets for primary and final energy consumption (see COM(2021) 558 final) of at least 9% in 2030 compared to the level of efforts under the 2020 Reference Scenario. The new way of expressing the level of ambition for the EU's targets corresponds to a reduction of 36% for final energy consumption and 39% for primary energy consumption respectively when compared to the 2007 Reference Scenario projections for 2030 (i.e. the current way to reflect the energy efficiency targets).

[123] As proposed in COM(2021) 557 final, i.e. an EU overall target of at least 40% renewable energy in gross final energy consumption by 2030 and a specific EU target of 1.1 p.p. annual increase in renewable energy in the heating and cooling sector.

[124] For example, the EPBD revision of brings an additional 18 Mtoe of final energy consumption savings out of 77 Mtoe needed between REF2020 and MIX. It therefore contributes 24% of the final energy consumption reduction effort.

also emerges. Bridging this gap corresponds to 10% of the primary energy savings effort between the REF2020 and MIX scenario. The impacts are most pronounced in the residential sector, where EPBD revision brings 41% of energy savings effort, and in the services sector, where EPBD revision represents 37% of the effort.

The impacts of EPBD revision are also significant on the renewables share, which becomes bigger thanks to energy savings but also thanks to an absolute increase in the amount of renewables in the H&C sector as deep renovations are often coupled with the installation of renewable H&C equipment (notably heat pumps). As a result, the overall RES share grows by 0.9 percentage points (p.p.) between MIXwoEPBD and MIX, which represents 18% of the effort between REF2020 and MIX. The change is more pronounced in the RES H&C share, which grows by 2.4 p.p., representing 46% of the effort.

Environmental impacts

The MIXwoEPBD variant, in the absence of drivers illustrating the EPBD revision, therefore results in particular in the underachievement of the energy target, which also impacts GHG, reducing the contribution to emission reductions by 0.6 p.p. to 2030. This assumes that the new ETS would not contribute to bridging the cap (carbon pricing assumed static compared to MIX) and would therefore not compensate for the reduced deployment of the EPBD revision.

The differences are the most pronounced in the building sector, where the EPBD revision would deliver up to 50% of the decarbonisation effort in the residential sector and up to 45% in the services sector.

Economic impacts

The MIXwoEPBD variant shows that in the absence of the EPBD revision, the system costs would fall by EUR 12 bn/year in 2021-30 (metric excluding carbon pricing and disutilities). This is explained by the fact that some investments in renovations would not take place. But the reductions on the side of investments are partly offset by increased expenditure for heating fuel and smaller savings in energy expenditure, which could be achieved by switching to renewables (many of them with lower operational costs). Put differently, the EPBD revision brings a 38% increase in total system costs between REF2020 and MIX, taking into account increased investment needs but reduced energy purchase expenditure.

Zooming in on the investments, the MIXwoEPBD variant shows that in the absence of the EPBD revision, investments would fall by EUR 34 bn/year in 2021-30. Put differently, the EPBD revision brings a 33% increase in total system costs between REF2020 and MIX. While the figure is significant, the reductions in energy purchase expenditure in the building sector must be also highlighted: over EUR 3 bn/year in 2021-

30. Renovations involve reducing operating expenditure, but at the cost of increased capital expenditure.

With clearly reduced fossil fuel expenditure, the fossil fuels import bill is also lower thanks to EPBD revision. The savings between MIX and MIXwoEPBD amount to EUR 13 bn over 2021-30 and amount to 12% of the effort between REF2020 and MIX.

Social impacts

Building-related energy expenditure as a share of private consumption increases by 0.2 p.p. in 2030 because of the EPBD revision as renovation investment costs will be higher than fossil fuel savings also for consumers.

Table 6.2: Key results of the MIXwoEPBD variant in comparison to MIX and REF scenarios

EU27 2030 results unless otherwise stated	**metric**	**REF**	**MIX**	**MIX-woEPBD variant**	**Difference MIX vs MIXwoEPBD**[133]	**Difference MIX vs MIXwoEPBD compared to difference MIX vs REF** [134]
Energy and environmental impact						
CO2 emission in residential sector	Mt CO2 eq	211.6	142.2	176.8	-34.6	50%
CO2 emission in services sector	Mt CO2 eq	91.2	69.1	79.1	-10.0	45%
CO2 emission in residential and services sectors	Mt CO2 eq	302.8	211.3	255.9	-44.7	49%
CO2 emissions reduction (intra-EU scope, excl. LULUCF)	Mt CO2 eq	2850.3	2376.0	2407.1	-31.1	7%
Total GHG emissions reductions (incl. intra EU aviation and maritime, excl LULUCF) compared to 1990	Mt CO2 eq	43.4%	52.9%	52.2%	0.6	7%
PEC2020-2030	Mtoe	1124.3	1021.9	1032.5	-10.6	10%
FEC2020-2030	Mtoe	883.0	806.4	824.5	-18.1	24%
FEC in residential sector	Mtoe	215.4	182.2	195.8	-13.6	41%

FEC in services sector	Mtoe	118.0	106.6	110.7	-4.2	37%
FEC in residential and services sectors	Mtoe	333.4	288.7	306.5	-17.8	40%
Overall RES share	%	33.2%	38.4%	37.5%	0.9 p.p.	18%
RES H&C share	%	32.8%	38.4%	35.6%	2.4 p.p.	46%
Economic impacts						
Investments (excl. transport) (2021-30)	€15 bn /year	296.7	402.0	367.6	34.4	33%
Energy purchase expenditure in buildings sector (2021-30)	€15 bn /year	463.6	451.9	455.3	-3.4	29%
Energy system costs excl. carbon pricing and disutility (2021-30)	€15 bn /year	1518.0	1550.1	1537.8	12.3	38%
Average price of electricity	€/MWh	157.9	157.7	157.5		no visible impact
Fossil fuels imports bill for the period 2021-30	bn €'15/10 years	2274.4	2159.7	2173.1	-13.4	12%
Social impact						
Energy-related expenditure in buildings (excl. disutility) share in private income	%	6.9%	7.5%	7.3%	0.2 p.p.	41%

Source: PRIMES

6.3 Environmental impacts

The environmental impacts of the policy options assessed cover energy use, GHG emissions, the use of materials, water and air pollutants. These impacts not only occur through changes in production or consumption patterns within the EU, but also in other countries that manufacture and trade products or materials imported into the EU. The impacts of the options have been assessed using the modelling tools described in detail in Annex D.

6.3.1 Impacts on building renovations and new buildings

The key dimension for assessing impacts of policy options for the revision of the EPBD is the transformation of the building stock and its energy performance over time. The dynamic of transformation is illustrated by the renovation of floor area to variable depths/intensities and by the energy performance of new builds.

The MEPS options relate to different segments of the building stock, which are also distributed differently across Member States.

Table 6.3: Building stock covered under MEPS[125]

	Segments of the building stock	Share of the building stock (EU average)	Differences across Member States in the share of the building stock covered
MEPS1	Worst performing buildings, rented/sold	On average rented every 18 years and sold every 50 years, with worst performing buildings representing a variable share of the buildings under transaction For residential buildings, the share of building transactions at EU level in 2018 was around 4%/year, including sales, renting and renting at reduced rates[126].	Could be large for residential buildings, depending on differences in the efficiency of the building stock (starting point) illustrated in Figure 2.1, ownership structure (Figure 2.7 for residential sector), the dynamics of the property and rental markets, and the share of small and large multi-family houses in residential buildings.
MEPS2	All worst performing buildings	Gradually covering all buildings by 2050, depending on the priorities of the national schemes	Could be large, reflecting the differences in the starting point (average efficiency of the building stock).
MEPS3	Non-residential buildings	Gradually covering up to 25.8% of the building stock	Moderate, with most countries close to average with some outliers (from 8.8% in Cyprus to 47.6% in Estonia). Figure 2.9
MEPS4	All buildings in which heating and cooling appliances are replaced	Approx. 4%/year (all stock replaced in around 25 years)	Expected to be moderate (national data not available)

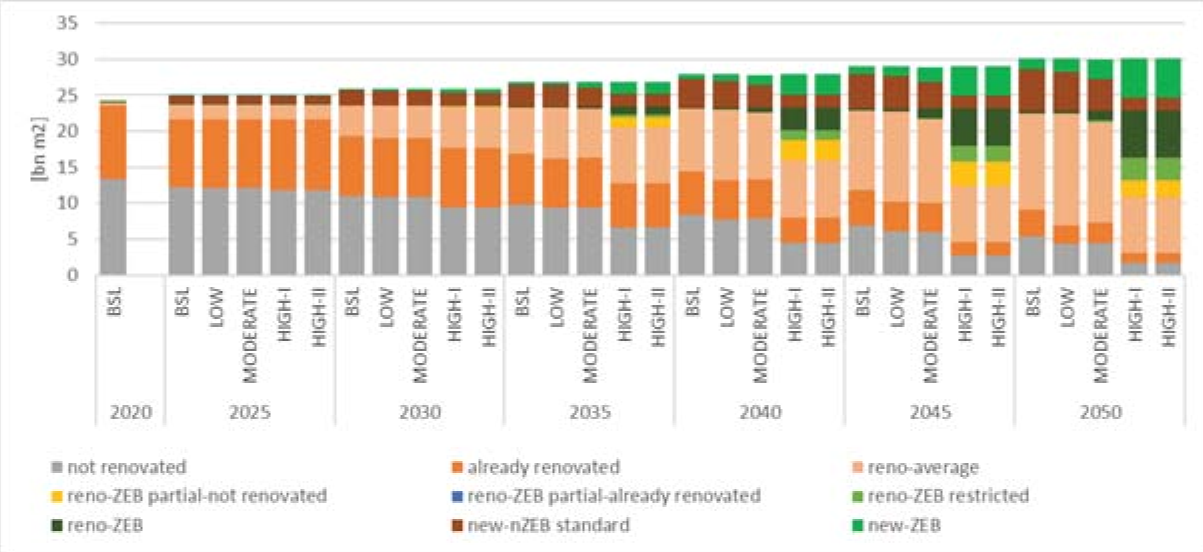
All MEPS sub-options will produce different effects depending on the starting point in each country, with more efforts in the countries with the largest share of inefficient buildings on the basis of EPC classes. MEPS2 has the potential to be more complete in terms of covering the whole stock gradually, although the effects would also depend on the specific pathway identified in Member States and adapted to the national conditions. MEPS1, MEPS3 and MEPS4 will only cover a limited subset of the building stock.

[125] See also Annex F on the differences related to the buildings to be targeted under MEPS schemes.
[126] Calculations based on Eurostat SILC microdata. For Denmark, Estonia, Latvia, the Netherlands and Finland, data was not available. The most recent reliable data for Romania and Bulgaria are from 2016, and for Hungary from 2017.

It is assumed that some 55% of buildings are not renovated at present, while around 43% have undergone some kind of renovation since they were first built[127]. Only 1.3% and 0.8% respectively have been renovated at average and deep renovation levels in 2020.

In the baseline scenario, the EU floor area is expected to be transformed over time by standard and shallow renovation (labelled ‘reno-average’), with only very low shares of ambitious renovation (labelled ‘reno-ZEB’). It is also expected that a small share of new buildings will go beyond the current new standard (nearly zero-energy buildings/NZEB) until 2050 and be built to a higher standard, which is referred to as ‘new ZEB’ (Figure 6.2). These assumptions reflect the historical trends in renovations and the most likely development under the current policy framework.

Figure 6.2: EU floor area development in the baseline and considered scenarios[128]



Source: Guidehouse et al.

The impacts on **floor area development** already become visible by 2030 in the most ambitious scenarios HIGH-I and HIGH-II, when stronger policy signals lead to more renovation activities. A slightly higher share of renovated buildings also stands out as a consequence of anticipating activities before the introduction of MEPS (Figure 6.1). The additional renovated floor area over 2021-2030 ranges from 16-17% in the LOW and MODERATE scenarios up to 23% in the two most ambitious scenarios. By 2050, the additional renovated floor area will reach 46-53% and 66% of the building stock respectively in the least ambitious and most ambitious scenarios. In the least ambitious

[127] This is why the building stock has two status quo levels in 2020 (‘not renovated’ and ‘already renovated’), to which different energy needs are associated for the scenario calculations.
[128] Based on Guidehouse (2021).

scenarios, almost all of the additional renovations are done at an 'average' level[129] all over the period up to 2050.

By contrast, in the most ambitious scenarios there is a progressive increase in 'depth' in the renovation of **existing buildings** after 2030, where ZEB renovations that achieve higher savings start to significantly upgrade 'not renovated' buildings and 'already renovated' buildings[130]. The high impact of the most ambitious scenarios comes not only from MEPS2, but also from the cumulative effects of the other measures in designed policy packages, notably DEEP2, LTRS3 and BRP3. The latter triggers a more systematic and effective approach to staged renovation. As for **new buildings**, no more NZEBs are built after 2030 in the HIGH scenarios, being replaced by a more ambitious ZEB standard[131]. In the least ambitious scenario, the new standard will be an incremental increase from current NZEB that will last until 2050, while the penetration of the ZEB standard will remain limited.

The effects are therefore very different across scenarios. While in the LOW and MODERATE scenarios a limited share of the building stock is renovated and shallow to medium renovation dominates, in the two most ambitious scenarios a gradual transformation of the existing building stock is achieved. These results can also be illustrated by the evolution of renovation rates as presented in Table 6.4.

Table 6.4: EU average renovation rates (average over 5 years period) and share of deeply renovated floor area in total renovated floor area

	2020	2025	2030	2035	2040	2045	2050
Average renovation rate in full renovation equivalent (over 5 yrs) [%total floor area]							
BSL	1.35%	1.47%	1.65%	1.72%	1.72%	1.72%	1.71%
LOW	1.35%	1.47%	1.85%	2.06%	2.06%	2.05%	2.05%
MODERATE	1.35%	1.47%	1.83%	2.01%	2.01%	2.23%	1.74%
HIGH-I	1.35%	1.47%	2.99%	3.60%	3.34%	2.29%	0.93%
HIGH-II	1.35%	1.47%	2.99%	3.60%	3.34%	2.29%	0.93%
Average share of deeply renovated floor area after 2020 (over 5 yrs) [% of total renovated area]							
BSL	1.0%	1.2%	1.4%	1.7%	2.0%	2.2%	2.6%

[129] For a detailed overview of the energy performance and corresponding savings attributed to each renovation category, see Annex D on 'Analytical methods'. 'ZEB partial' are buildings on the way to 'retrofit ZEB' level, but reach this in several steps.

[130] In the high ambition scenarios, the average renovation is no longer implemented after 2035 due to the progressive introduction of stricter requirements and corresponding enabling conditions in favour of 'ZEB' renovations. As MEPS2 drives buildings retrofitted to ZEB level by 2050, in the high scenarios 'ZEB partial' first builds up after 2030, and then decreases again towards 2050 – by then, most 'ZEB partial' buildings will have turned into (full retrofit) 'ZEB'.

[131] For ZEBs, for new constructions a standard definition of 'passive house' is applied for modelling purposes. The impact of potential reductions of embodied carbon content due to ZEB2 is not modelled as it goes beyond the boundaries of the baseline assumed, which only covers CO_2 from energy use. However, the existing literature helps us understand the magnitude of the emissions addressed and the potential for reductions (see Annex H).

LOW	1.0%	1.2%	1.4%	1.6%	1.9%	2.2%	2.5%
MODERATE	1.0%	1.2%	1.6%	3.3%	6.0%	9.6%	10.8%
HIGH-I	1.0%	1.2%	3.9%	18.9%	39.6%	53.6%	59.2%
HIGH-II	1.0%	1.2%	3.9%	18.9%	39.6%	53.6%	59.2%

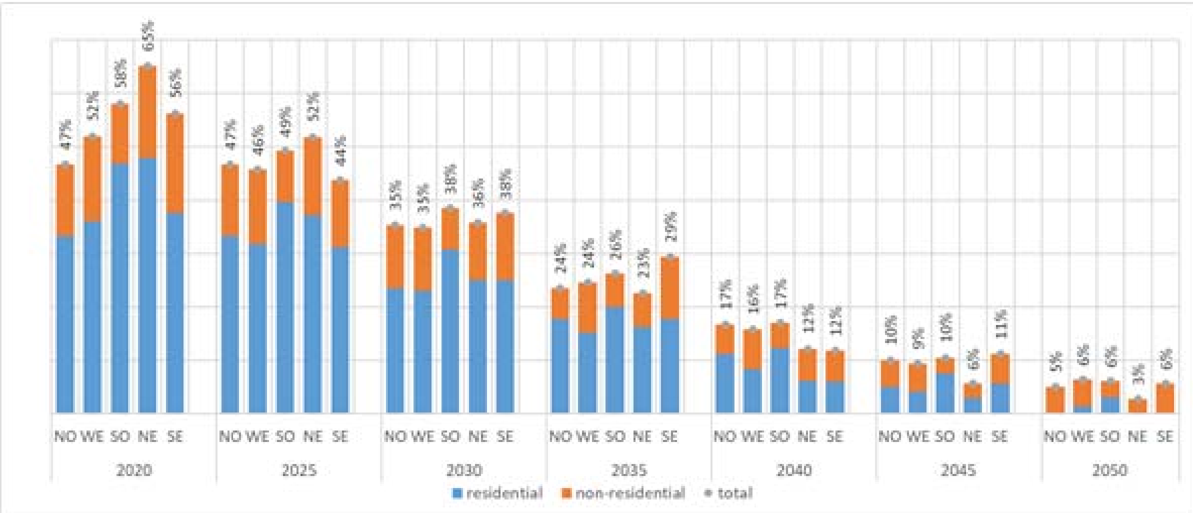
Source: Guidehouse et al.

While the building stock was renovated at an average rate of 1.35% in 2020, the rate increases up to 3% in two HIGH scenarios by 2030. After peaking at 2-3.6% in 2035-2040 across scenarios, the average renovation rate starts to decrease after 2040. As the average renovation rate does not provide information about the level of energy savings achieved due to renovations, it is interesting to also look at the share of deeply renovated floor area (see table above).

Deep renovation takes off in the two HIGH scenarios after 2030, facilitated by the introduction of stricter minimum energy performance standards (MEPS1, 2 and 4). The average share of deeply renovated floor area in total renovated floor area increases from 1% to around 19% in 2035, reaching 60% in 2045-2050. By contrast, in the LOW and MODERATE scenarios the share of deeply renovated floor area remains at 1.6% and 3.3% respectively by 2035 and reaches 11% by 2050.

Thanks to building renovation, the share of worst performing buildings (those 'not renovated') is progressively reduced across all options. In HIGH scenarios, the floor area of worst performing residential buildings decreases gradually towards zero by 2050 through the implementation of MEPS1.

Figure 6.3: Evolution of the floor area of worst performing building stock in the EU regions considered in the model, High I scenario



Source: Guidehouse et al.

There are however differences across the EU, reflecting the different ages of building stock in Member States. The distribution of worst performing buildings, both residential and non-residential, varied across EU regions in 2020 – from 47% of the building stock floor area in the Northern region to 65% of the floor area in the North-Eastern region (Figure 6.3). Residential buildings represent the biggest part of the worst performing floor area in all regions, i.e. 2-3 times bigger than the floor area of the worst non-residential buildings.

6.3.2 Impacts on energy consumption and GHG emissions

Table 6.5: Energy and GHG emission reductions at EU level across scenarios

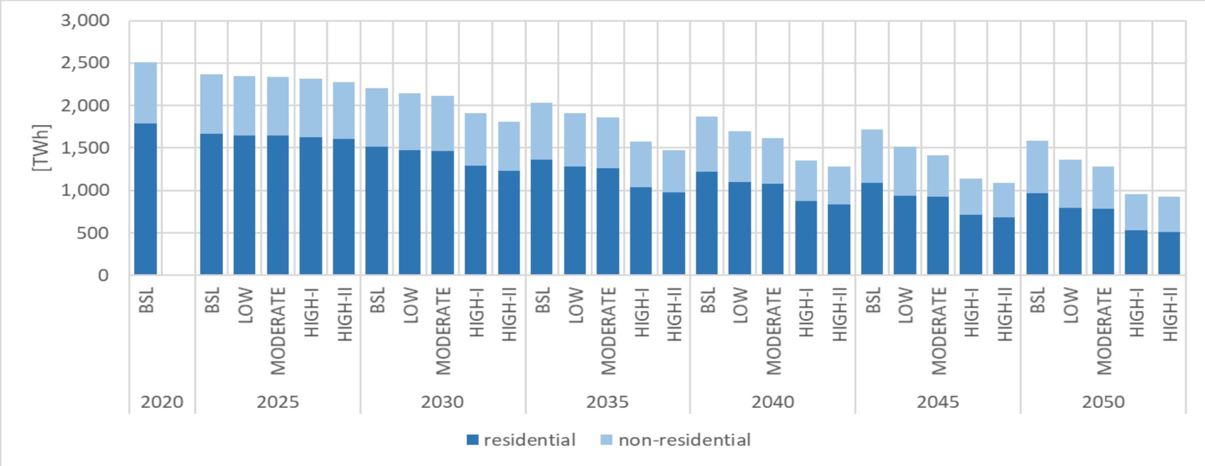
		2030				2040				2050			
Main indicator	**[unit]**	**LOW**	**MOD**	**HIGH-I**	**HIGH-II**	**LOW**	**MOD.**	**HIGH-I**	**HIGH-II**	**LOW**	**MOD.**	**HIGH-I**	**HIGH-II**
Energy savings in space heating/cooling and DHW[132]	[% from BSL]	-2.4	-3.6	-11.7	-16.1	-7.8	-11.3	-24.4	-28.0	-11.7	-15.8	-34.0	-36.0
GHG emission[133] **savings in space heating/cooling and DHW**	[% from BSL]	-3.1	-4.2	-22.8	-28.5	-10.4	-15.7	-49.7	-55.4	-14.4	-20.6	-53.5	-57.1

Source: Guidehouse et al.

The options from LOW to MODERATE show a progressive **reduction in the final energy consumption** used for heating and cooling purposes across scenarios. In 2030, the reduction is in the range of -2% to -11% across scenarios compared to the baseline (Table 6.5, Figure 6.4). In HIGH-I and II, the introduction of MEPS at scale leads to an earlier and then much steeper decrease compared to the baseline scenario. While the reduction in energy consumption is limited for the LOW and MODERATE scenarios, the two HIGH scenarios reduce it by 11-12% compared to the baseline in 2030. The decrease in energy demand in the two HIGH scenarios becomes even more significant in 2040 (-24% compared to baseline) and reaches -34/-35% towards the mid-century.

Figure 6.4: Final energy consumption for space heating across considered scenarios[134]

[132] DHW=Domestic hot water.
[133] "GHG emissions" includes direct emissions from fossil fuel combustion in the buildings as well as indirect emissions from the power and heat production sector corresponding to the electricity and heat used for heating, cooling and domestic hot water.
[134] Based on Guidehouse (2021).

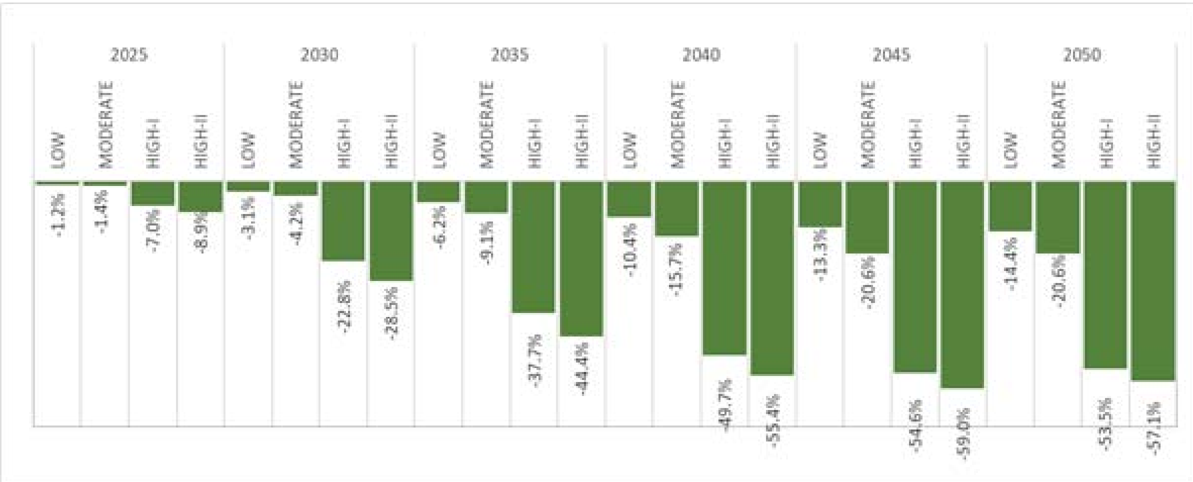


Source: Guidehouse et al.

Besides absolute energy consumption values in HIGH scenarios, the average **annual energy savings** achieved compared to 2020 levels sees an increase from 1.5% between 2020 and 2025 to a peak of 3.2% between 2025 and 2030. The annual energy savings rates will gradually decrease towards 2050 by around 1.1-1.5% in LOW and MODERATE and by 2.1% in HIGH-I and II. The HIGH scenarios therefore achieve almost a doubling of the energy savings in 2030-2035 compared to the baseline scenario.

The reduction in energy consumption resulting from higher rates and deeper energy renovations induced by MEPS, together with higher standards in new construction, leads to a progressive decrease in **GHG emissions** in the building sector in 2020-2050 (Figure 6.5).

Figure 6.5: Evolution of the GHG emission reduction for heating, cooling and DHW in buildings compared to baseline scenario



Source: Guidehouse et al.

In 2030 and compared to the baseline scenario, the reduction in GHG emissions from heating, cooling and domestic hot water (DHW) is in the 3-4% range for LOW/MODERATE scenarios and around 23% in the HIGH-I and HIGH-II scenarios. Around 66% and 62% of these emission savings are achieved in residential buildings in

LOW/MODERATE and HIGH-I and II scenarios respectively[135], while the remaining share is achieved in non-residential ones. These emission reductions are achieved thanks to a combined uptake of deeper and accelerated energy renovations triggered by MEPS1 and MEPS2[136]. In this case, the introduction of DEEP2, LTRS3 and BRP3 in the two HIGH scenarios also amplifies the effect of MEPS.

This emission reduction will be achieved by (i) reducing the energy demand of buildings and increasing the use of renewable energy; and (ii) by a gradual shift from fossil fuels to renewable and electricity-based building systems. As a result, part of the direct emissions of buildings will be shifted to the power and heat sector. The share of direct emissions in the total emissions of buildings – around 80% in 2020 – will therefore gradually decrease in 2030 to around 77-79% in LOW/MODERATE and to 71% in the two HIGH scenarios respectively.

Compared to the baseline, all considered scenarios have a consistent long-term impact. This leads to a reduction of GHG emissions from heating of 14-21% in LOW/MODERATE scenarios and 53-55% in the two HIGH scenarios by 2050.

When comparing the embodied GHG emissions resulting from renovation works (i.e. from the materials used such as insulation) with the reduced operational emissions after renovation, case studies show that renovation can bring about significant environmental gains. For old (poorly/non-insulated) buildings, the material-related impact of energy renovation is low, whereas gains in terms of operational energy are high[137].

Studies of embodied GHG emissions in buildings have shown that the addition of embodied emissions caused by the renovation of an existing building, depending on the nature and depth of the renovation works and the materials used, is typically less than 50% of the embodied emissions for a new building (i.e. less than 125–200 kg CO2eq./m2). It can be much lower if the renovation focuses, for example, on insulation and heating/cooling system improvements without major structural changes. If a renovation using materials with modest levels of embodied emissions, together with decarbonised energy supplies (e.g. renewable electricity), is therefore able to successfully reduce the operating emissions from an existing building to near zero, then the period during which the cumulative emissions are greater than they would have been without the renovation can typically be less than about 3 years[138] (typical values of embodied GHG

[135] This relative distribution of emissions savings between residential and non-residential will gradually decrease by 2050 to 60-64% and an almost equal share (52%) as in non-residential buildings (48%) in LOW/MODERATE and HIGH-I and II scenarios respectively. The lower share of emissions savings in non-residential buildings from the MODERATE scenario is explained by MEPS3, which addresses only large non-residential buildings and is implemented later than others.
[136] The demolition of buildings creates a false improvement in building stock as it reduces the floor area. This effect is however very limited as demolition rates are assumed to be 0.1-0.2% and constant across scenarios.
[137] CA EPBD May 2021, LCA to combine energy and material performance, BBRI.
[138] EASAC policy report 43.

emissions per square metre of floor area for new buildings lie between 250 and 400 kg of carbon dioxide equivalent per square metre (kg CO2eq./m2), whereas the operating GHG emissions from existing buildings typically lie between 30 and 50 kg CO2eq./m2 per year).

The projected GHG emission reductions from the LOW and MODERATE scenarios (3-4%) are considerably lower compared to the reduction level of around 15% (compared to reference) attributed to the EPBD contribution by the counterfactual scenario 'MIXwoEPBD' (Section 6.2). At the same time, the GHG emissions reduction of 23% in the two HIGH scenarios appears more comparable to that attributed to the EPBD.

Similarly, the energy savings in final energy consumption of residential and services sectors by 2030 for LOW and MODERATE scenarios (2.4-3.6%) appear low compared to the projected energy savings of 5.3% from the MIXwoEPBD scenario (compared to reference). However, the energy savings in the HIGH scenarios are by comparison more pronounced.

6.3.3 Air pollution, indoor air quality, water and material use

Table 6.6: Summary of main results on air pollution, water and material use at EU level

		2030				2050			
Main indicator	[unit]	LOW	MOD.	HIGH-I	HIGH-II	LOW	MOD.	HIGH-I	HIGH-II
Air pollution									
Sox	[% from 2020]	0.1%	0.1%	-1.2%	-1.1%	-1.7%	-1.9%	-5.9%	-7.4%
Nox	[% from 2020]	0.2%	0.2%	0.3%	0.3%	-0.4%	-0.5%	-1.0%	-1.4%
PM 2.5 and 10	[% from 2020]	0.1%	0.1%	0.1%	0.1%	-0.3%	-0.3%	-0.8%	-1.1%
Water use	[% from 2020]	0.0%	0.0%	0.4%	0.4%	0.0%	0.0%	0.3%	0.3%
Material use	[% from 2020]	0.2%	0.2%	2.2%	2.2%	-0.2%	-0.3%	1.1%	0.9%

Source: Guidehouse et al.

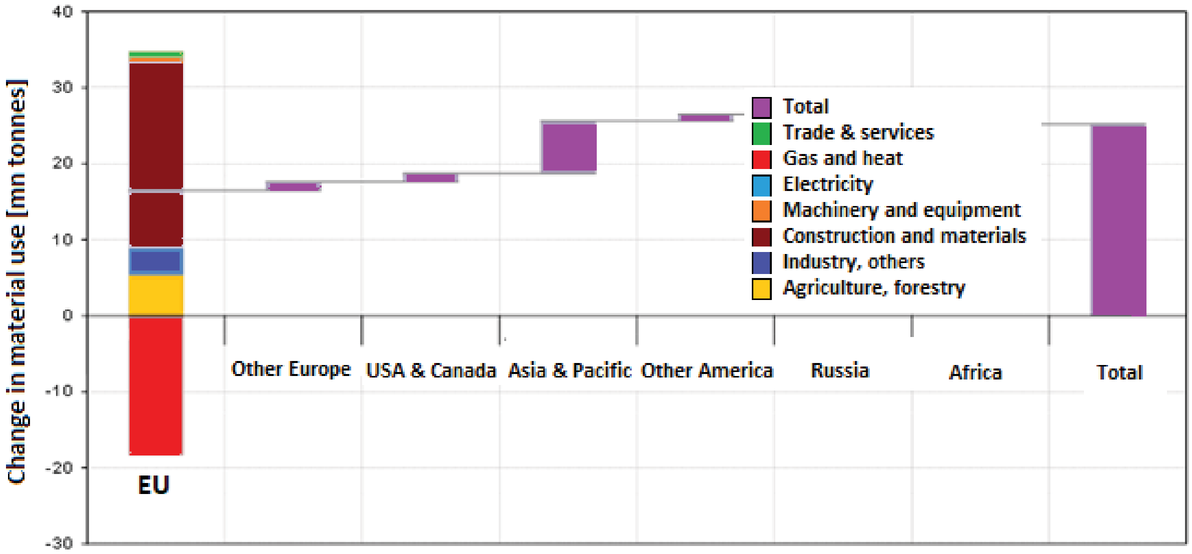
Significant non-energy co-benefits can be achieved thanks to policies that lead to the increased energy renovation of buildings. The **air pollutants** that are reduced as a result of energy savings are SOx, NOx and particulate matters (PM 2.5 and 10, Table 6.6). Their reduction generates co-benefits for human health and ecosystems.

Building renovation also has an impact on health-related factors linked to **indoor air quality** like proper ventilation flow, indoor temperature, air pollution, noise or exposure to toxic substances. Thermal insulation of different parts of buildings, ventilation and renovation in general can have different positive and negative aspects for human health[139]. During the consultation phase, several stakeholders expressed the need for EPBD policies to contribute to better indoor air quality. The increase in renovation activities triggered by MEPS would have effects on the **use of materials for**

[139] Mzavanadze, N. (2018). COMBI: WP5 Social welfare: Final report: quantifying energy poverty-related health impacts of energy efficiency.

construction works[140]. Building renovation usually requires material extraction and use in construction. Demolition activities as well as construction also have impacts on waste production and the environment. Minerals have the highest share of all materials in buildings, comprising around 65% of total aggregates (sand, gravel and crushed rock), and approximately 20% of total metals are used by the construction sector[141]. Growth in construction activities will therefore increase the pressure on the environment. However, embodied CO_2 emissions emanating from building materials could potentially be reduced by 50% or more using circular approaches[142].

Figure 6.6: Impact of renovation and new-build investment on material consumption within the EU 27 and rest of the world, 2030 (difference to baseline)[143]



Source: Guidehouse et al.

Figure 6.6 shows that investments in renovations and in highly efficient new constructions in the high ambition scenario II lead to additional material use of some 16 million tonnes in 2030 within the EU compared to the baseline, and to an additional 8 million tonnes in other countries. This translates into around 0.2% and 2.2% total additional resource use in 2030 in LOW/MODERATE and HIGH-I AND HIGH-II scenarios compared to the baseline. This is a net effect between the increase in resources used for the construction and material sector and a decrease in resources used within the gas and heat sector and also petroleum refining (included in industry) and fossil-based

[140] For instance iron, aluminium, copper, clay, sand, gravel, limestone, wood, and building stone.
[141]Herczeg et al. 2014: Resource efficiency in the building sector; available at: https://ec.europa.eu/environment/eussd/pdf/Resource%20efficiency%20in%20the%20building%20sector.pdf
[142] Material Economics 2018: The Circular Economy: A Powerful Force for Climate Mitigation. Available at: https://materialeconomics.com/publications/the-circular-economy-a-powerful-force-for-climate-mitigation-1
[143] Exiobase modelling.

electricity (included in electricity). The increased materials mainly come from the EU, although around 30% of the construction materials are traded from Asia-Pacific.

Compared to the baseline, **water usage** rises by around 0.4% and 0.3% by 2030 and 2050 in the most ambitious scenarios. Water usage mainly increases in the agricultural and forestry sector that provides products and services to the sectors directly affected by renovation and new build activities.

6.4 Socio-economic impacts

The increase in renovation activities triggered by the implementation of MEPS will have positive effects of variable intensities across the building renovation value chain, which is quite complex and fragmented[144]. It includes on-site construction activities, together with raw materials supply and the manufacture of construction materials and products, mostly supplied by upstream sectors.[145] Value is unevenly distributed along the chain with developers, material distributors and logistics capturing a rather large share of the value pool[146]. A large number of suppliers are engaged in building renovation, providing services, and intermediate products from sectors further up the value chain, including materials, machinery, electrical equipment, chemicals, metal products, and more. Small and medium sized enterprises (SMEs) play a key role in the build environment. Over 99% of the construction industry ecosystem consists of SMEs[147], either supplying essential technologies and materials or providing services locally in their area. Capacity limitations on their side might limit the renovation rate that can be achieved. New technologies also require know-how and capacity development. All the operators across the value chain would be affected by a positive increase in value and activities, with positive corresponding effects on employment.

While energy costs would be reduced for end-users, building owners would incur investments and other compliance costs, and public administration would face administrative and enforcement costs.

6.4.1 Investments, costs and property values

6.4.1.1 Investments

MEPS and ZEBS uptake results in higher **investments in building renovation and new construction**. Investments sharply increase across scenarios after 2025, when the new standards come into force and require worst performing buildings to be renovated. Compared to the baseline, the relative increase in investment in 2030 is +18% / +22% in

---

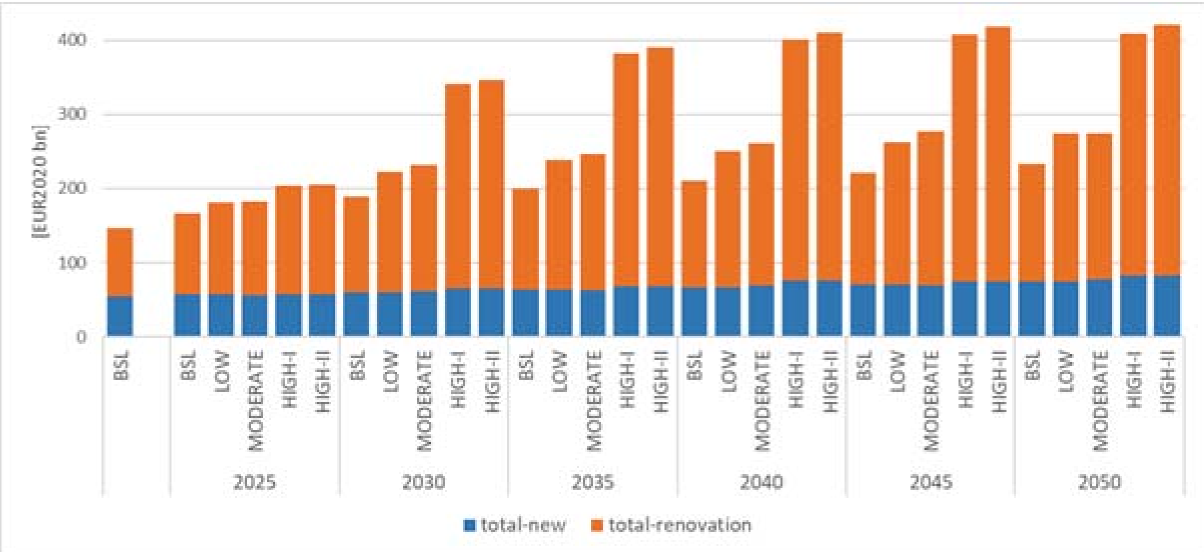
[144] Groote and Lefever, 2016.
[145] Ecorys et al., 2016.
[146] McKinsey & Company, 2020.
[147] https://ec.europa.eu/growth/sectors/construction_en#:%7E:text=The%20construction%20industry%20is%20very,social%2C%20climate%20and%20energy%20challenges

LOW/MODERATE scenarios and around +80% / +83% in HIGH-I/HIGH-II scenarios, slightly decreasing towards 2050 (Figure 6.7).

As explained in relation to environmental impacts, this relates to the 'maximum effect' needed, while the national MEPS scheme could be of lower intensity depending on the specific set-up and interaction with other instruments. The majority of the investments relate to renovations triggered by MEPS[148], while the rest relates to the compliance of new constructions with the ZEB standard. This is in line with the analysis underpinning the Renovation Wave strategy. Following the Climate Target Plan (CTP), the strategy identified that building renovation is one of the sectors facing the largest investment gap in the EU[149].

The dimension of investments is also linked to the financing challenge for building renovations. The supporting tools included in each option are expected to have effects in providing a comprehensive policy framework to facilitate the targeting of available funds to the right renovation projects. While the deep renovation definition would help investors targeting money towards integrated and staged renovation packages – providing a longer-term perspective to building owners – building renovation passports will help identify case-by-case and from a technical point of view the most suitable and cost-efficient refurbishment packages according to building characteristics.

Figure 6.7: Investment cost development at EU level for renovation and new construction (in billion EUR2020/year)[150]



[148] Around 75% in LOW/MODERATE and 81% in HIGH-I/HIGH-II.

[149] The analysis underpinning the CTP and Renovation Wave strategy indicated that to achieve the proposed 55% climate target by 2030, around EUR 275 billion of additional investment in building renovation is needed every year. For the EPBD and compared to the baseline scenario, the additional annual investment costs in the two HIGH scenarios are estimated at around EUR 152-157 billion in 2030 (in fixed 2020 prices).

[150] Based on Guidehouse (2021).

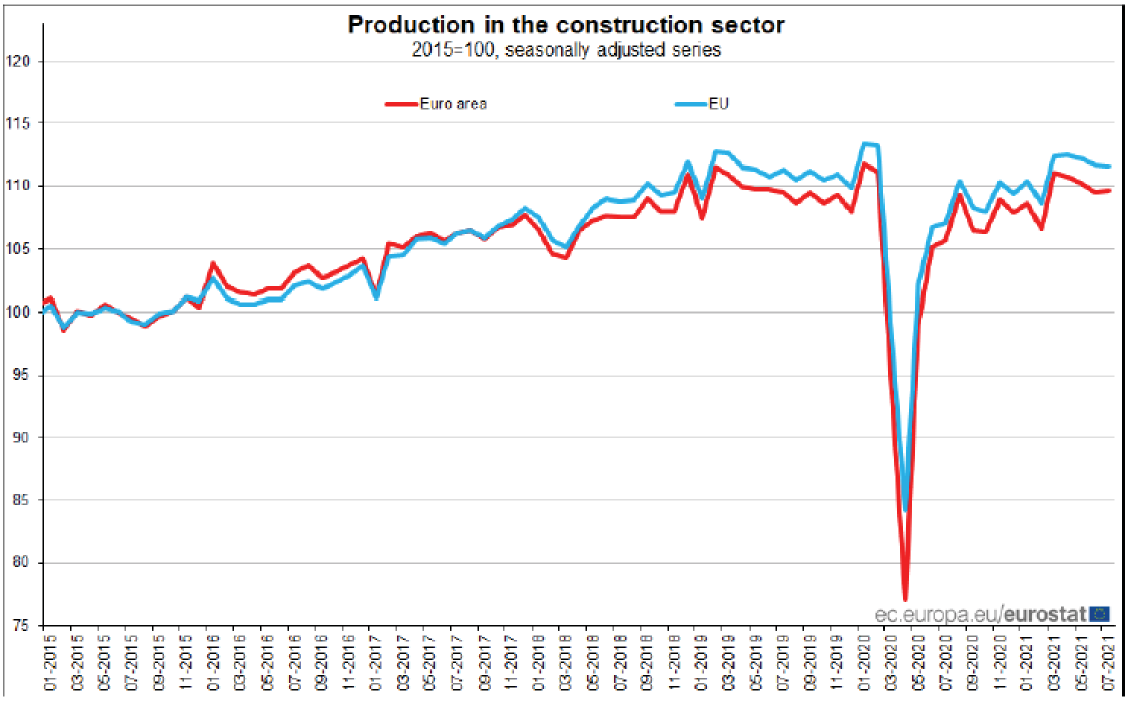
Source: Guidehouse et al.

6.4.1.2. The challenges of increasing capacity in the supply markets

An increase in demand for construction materials, besides generating environmental impacts as mentioned in Section 6.3 above, could also create pressure on markets. This would result in higher prices and potential difficulties in sourcing materials.

This effect has to be carefully considered in the light of the price increases and imbalances observed since May 2020[151]. The COVID-19 pandemic and related containment measures, as well as the follow-up recovery plans, have had a significant impact on the EU industry. On the supply side, the pandemic has led to supply shocks disrupting supply chains within and outside the single market. Global shipping costs for instance have seen huge increases, with container prices increasing several-fold during the pandemic (almost 400% between October 2020 and May 2021). On the demand side, the strong economic recovery during 2021, together with unprecedented public investment plans in the EU, China and the USA, have increased pressure on demand for products. In addition, consumers have partially reallocated their expenditure from services to goods.

Figure 6.8: Production in the construction sector 17/09/2021 (Eurostat)



Source: Eurostat

[151] On this issue, see also Annex D, 8.1 Energy and environmental impacts.

The construction sector has been badly affected as regards wood and metal products and components. In some cases, prices have reached their highest levels since 2008-2011 (the end of the last commodity boom). Between May 2020 and June 2021, the price of aluminium, copper and steel increased by more than 50%, and timber by around 40%. The inflationary pressure has been less significant for glass, concrete and cement, at less than 10%. This is mainly due to the fact that they are mostly produced locally. The delays and increase in prices of raw materials have affected the construction ecosystem, which is largely dependent on primary inputs. During the pandemic, construction output suffered a major decline as a result of lockdown (Figure 6.8) and, in some Member States, the temporary closure of construction sites. However, Eurostat data[152] indicates that EU production in construction increased by 3.8% in July 2021 compared with a year earlier.

As inflationary prices are mainly due to short-term imbalances between supply and demand factors, monitoring and analysis indicate that such steep increases are at least temporary in part. Supply-side issues are expected to be progressively resolved by the easing-off of restrictions on the movement of goods (mainly on freight disruptions), customers' partial move back to services and supply capacities' adaptation to higher demand (supply elasticity, via new investments).

However, macroeconomic trends make it unlikely that commodity prices will fully return to pre-pandemic levels. Global growth is expected to be 4.9% in 2022[153]. Demand, including in the construction sector, is expected to continue to be supported by government support measures and low interest rates until at least 2023 – the date when stimulus packages will start to shrink (the EU Recovery and Resilience Facility in particular will finance reforms and investments in Member States until 31 December 2026). Around that period, the HIGH-I/HIGH-II set of options will start triggering additional renovation works. It is therefore expected that the additional stimuli triggered by the EPBD revision will come at a moment in time (after 2025) in which the current temporal imbalances would either be compensated by additional capacity or prices would have been set at higher levels compared to their historical level. In particular, the use of materials for construction is expected to increase by 7.8% in the HIGH-I/ HIGH-II scenarios in 2030 and by 6.9% and 7.3% respectively in 2050 compared to the baseline[154].

On insulation works specifically, material accumulation in the EU (mainly roads, bridges and buildings) was 2,944 million tonnes in 2019, of which non-metallic minerals (sand, gravel) 2,516 million tonnes, metal ores 324 tonnes, wood 84 tonnes and fossil energy materials/carriers 20 million tonnes. Roughly 60% of insulation materials is glass wool

[152] Eurostat Euroindicators 107/2021: https://ec.europa.eu/eurostat/documents/2995521/11563279/4-17092021-BP-EN.pdf/edff43b7-5ef5-01c8-2cf8-f572825bab56?t=1631867055642
[153] Source: IMF World Economic Outlook Update July 2021.
[154] Based on Guidehouse et al. (2021).

or stone wool (non-metallic minerals), while the rest is mainly divided between fossil-based and renewable materials. A typical average density for insulation results in roughly 5-10 million tonnes annual flow for insulation materials, meaning less than 0.33% of the total yearly material accumulation. Compared to the above-mentioned total flow of raw materials, a doubling of the use of insulation materials does not appear to be a reason in itself for causing a scarcity of materials, as it would only lead to a very low percentage growth in material flows.

On machinery and equipment, in particular heating systems, demand is expected to grow by 4.4%/4.8% in the HIGH-I/HIGH-2 options by 2030 and by 4.5%/5% by 2050 compared to the baseline[155]. Unlike insulation materials, which lead to material accumulation in the building stock, the replacement of heating systems does not add material to the building stock. The majority of heating systems consist of metal. According to Eurostat material flow data, they already have a high recycling rate in waste treatment (around 90%). For this reason, a scarcity of materials for heating systems appears to be rather improbable, as the substitution of raw materials with secondary ones could compensate for the additional demand.

In addition, overall production in the construction industry in the EU is significantly below – more than 10% – the level reached in 2008[156]. This gap illustrates the construction industry's cyclicality and its capacity to expand relatively quickly to its pre-financial crisis levels and beyond, provided the appropriate conditions are met.

The historical capacity of market expansion together with the unprecedented global post-COVID market conditions could lead to a progressive cooling-off over time of the current price shock. However, the linked risks of high prices and lack of key materials and products on the renovation markets cannot be excluded for the future, and other shocks could also arise. Climate change and the global integration of value chains in particular will lead to higher shock frequency and severity in the future. Shocks affecting the supply of materials could stem from events including, but not limited to, extreme climatic events, financial crises, another pandemic, cyberattacks or trade disputes. It is however not possible to accurately quantify upstream the impact of such potential future shocks on the production, delivery and prices of materials in 2030 and 2050.

There are nonetheless mitigation factors that can be supported. Section 8.4 on the 'Challenges of the proposed measures' lays down the conditions to further ensure market scalability and limit those risks.

---

155 Ibid.

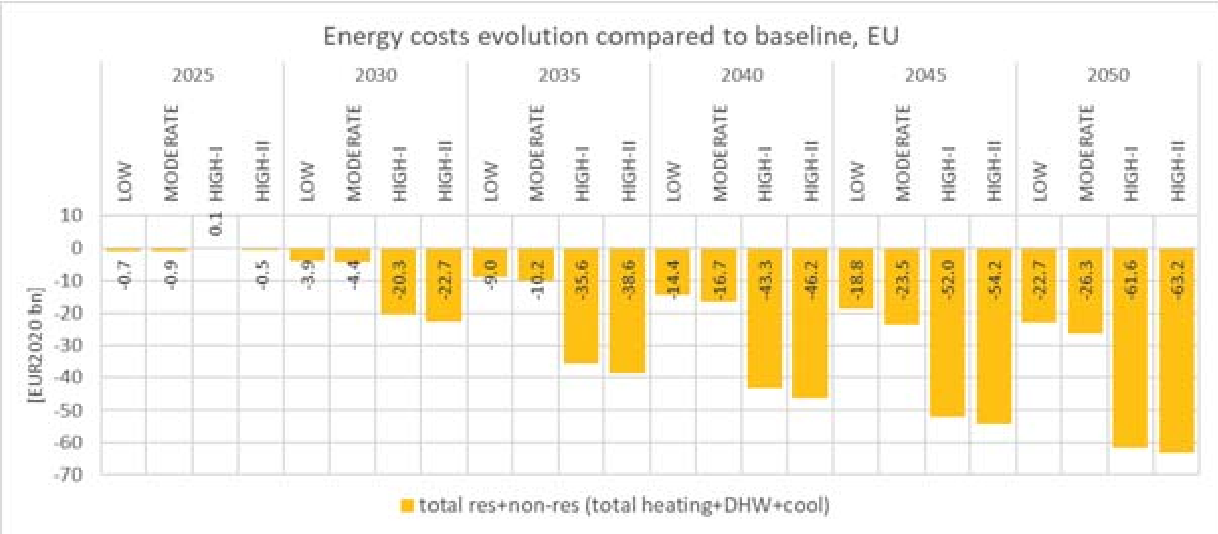
156 Based on Eurostat data from [sts_copr_m]; with an indicative index of 100 in 2015, by way of comparison, production was 113 in February 2020 and 111 in July 2021, compared to the record of 128 in February 2008. Production in construction means the output and activity of the construction sector. It measures changes in the volume of output.

6.4.1.3 Impacts on energy expenditure, investments and their distribution across income groups and regions

The counterpart of high upfront costs in building renovation, which becomes necessary to implement MEPS, is a reduction of the energy needs of the building, and with it the energy costs to be faced by building occupants.

Figure 6.9 shows how total energy costs in all buildings[157] develop between 2020 and 2050. In 2020, around 80% of energy costs are spent on residential buildings, while only around 20% are linked to non-residential buildings. Compared to 2020, energy costs for heating in the baseline scenario are projected to increase by 17% in 2030, driven by the increase in energy consumption and higher energy prices[158].

Figure 6.9: Energy costs at EU level in the considered scenarios compared to baseline[159]



Source: Guidehouse et al.

The introduction of MEPS and ZEBs has clear effects in **reducing total energy costs**. These become progressively more significant over time (together with more stringent standards) and with a more comprehensive combination of MEPS, with maximum effects in the HIGH scenarios. In 2030 compared to the baseline, the energy cost savings will be around 1.7% in the MODERATE scenario and around 8% in the HIGH scenarios. The impact becomes visible after 2025 due to anticipation effects and first obligations before 2030. In the modelled scenarios, there is a steep decrease in energy costs between 2030 and 2050, induced by a decrease in the energy needs of buildings through implemented measures. The annual energy costs will therefore reach EUR 223 billion by 2020 in the baseline scenario, EUR 197 billion in the MODERATE scenario and around EUR 161

[157] This applies to building services covered by the EPBD, i.e. heating, cooling, ventilation, DHW; other uses, e.g. household appliances, are not included.

[158] Energy price assumptions have been aligned to those used in all the proposals of the 'Fit for 55' package. See Annex D on analytic methods for more details.

[159] Based on Guidehouse (2021).

billion in the two HIGH scenarios. Despite increased energy prices, this means that energy savings in the MODERATE scenario and in the two HIGH scenarios will be around 12% and 28% of the total energy costs in 2050 in the baseline scenario.

It is important to mention that as the baseline only accounts for policies already in place, the introduction of a **carbon price** for heating fuels and its effect on energy prices is not included in the analysis of impacts of energy costs. An extension of ETS to the building sector would cause an increase in heating fuel costs (for fossil fuels), which is expected to reach around EUR 48/tonne in 2030 in the CTP MIX scenario. While providing for an additional incentive to a fuel switch and therefore to more efficient heating appliances that will improve the performance of buildings, it would also lead to an increase in the cost of GHG-intensive heating faced by final consumers. However, an ETS extension would also allow governments to raise the necessary funds to tackle energy poverty and help vulnerable customers.

The reduction of costs in the energy bills of consumers resulting from the implementation of MEPS would be greater if there is a carbon price. The higher the carbon price, the lower the payback period for renovation investments.

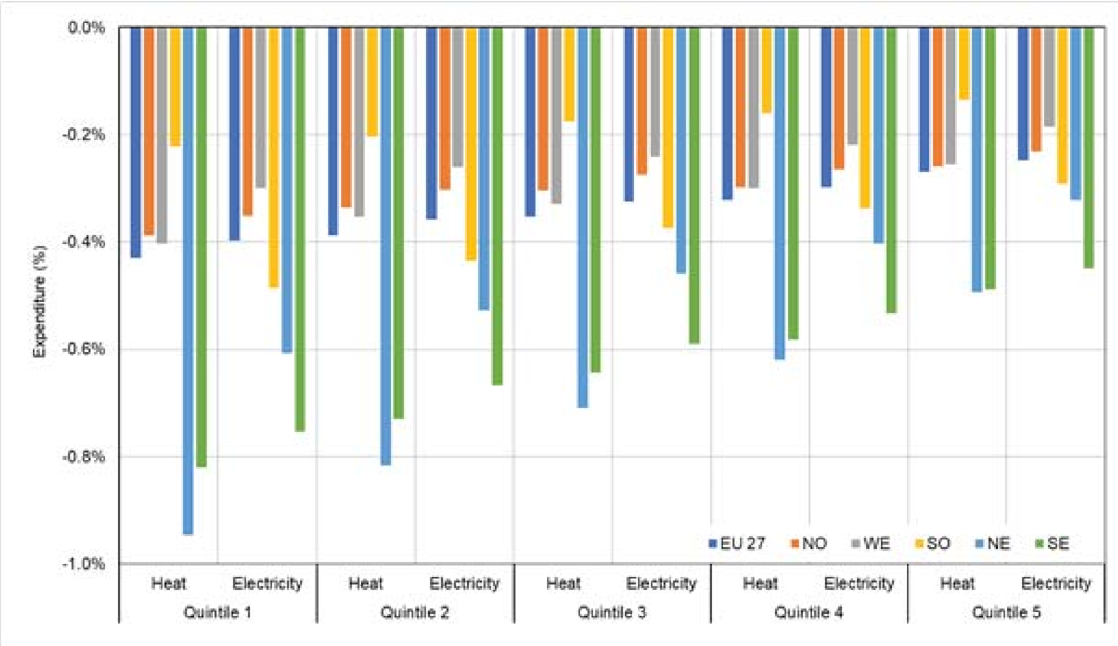
The impact on the share of expenditure that households need to use for energy is different across income groups. For low-income households, the share of energy expenditure in total consumption expenditure is much higher than for higher-income households. Renovations and subsequent energy savings in their homes therefore result in energy savings with positive impacts on energy poverty alleviation. A change in energy expenditure through renovation helps households with lower incomes, in particular those that live in worst performing buildings and are able to save the most.

Figure 6.10 shows the difference between HIGH-I and baseline at EU-27 and EU regional level regarding the share of heat and electricity expenditure in total consumption expenditure by income quintiles in 2030. The distributional impact depends on a number of key issues: building stock efficiency, climate conditions of the Member States, the energy source and energy amount used for heating and electricity combined with the disposable income of EU households. Data on building stock efficiency in the EU and its link to household income and building performance is incomplete. Therefore, the following analysis is based on assumptions about the allocation of energy savings resulting from building renovation measures. Reductions in energy expenditure are attributed to income quintiles according to the expenditure shares in the baseline. This is an assumption taken within the analysis to allocate savings across income groups. It implicitly assumes that renovation projects with roughly the same efficiency improvements are distributed evenly across income groups.

The results show larger savings for households in the lower quintiles for the EU-27 in total. The first quintile saves around 0.8% of energy expenditure in HIGH-I, while the fifth quintile saves around 0.5%. Since low-income households have to spend proportionally more of their income on energy, they also save more within the HIGH-I scenario. A shift in this assumption towards increased renovation of worst performing multi-family buildings would imply an even more pronounced savings effect for low-income households. North-east and south-east EU countries show the highest decrease in energy expenditure. The building stock likely included a higher range of worst performing houses. This results in higher savings.

Due to a lack of data on building stock efficiency, the proportion of energy expenditure savings especially for low-income households in the first quintile is subject to sensitivity: if energy efficiency improvements are predominantly made in buildings inhabited by low-income households, savings would be more pronounced, in particular relating to overall expenditure.

Figure 6.10: Difference between HIGH-I and baseline: share of heat and electricity expenditure on total consumption expenditure by income quintiles for EU-27 (2030)



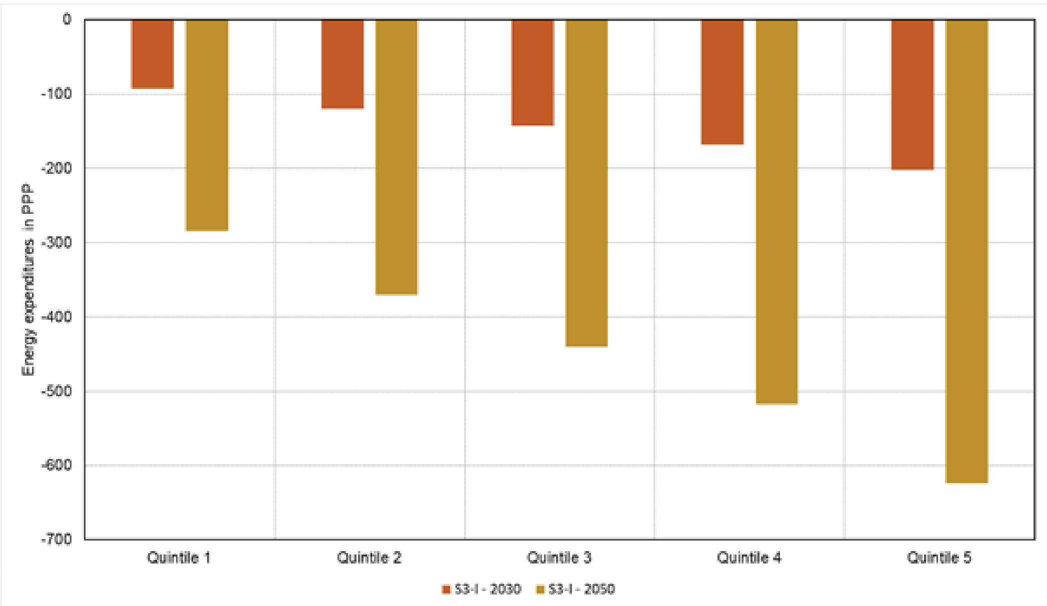
Source: Guidehouse et al. based on Eurostat (hbs_str_t223) and own calculation (explanation quintiles: quintile 1 = lowest income households to quintile 5 = highest income households)

In addition to improving building efficiency through renovation measures, heating and cooling technologies play a major role in energy expenditure. The replacement of old heating technologies can have a large impact on low-income households. From the assessment of options, it seems that as income rises, the share of household income spent on heating energy declines. In Member States with lower mean incomes, expenditure on heating energy is generally higher. This indicates that heat is a necessary good and does not readily respond to changes in income. However, energy prices and climatic conditions in the respective Member States also play a large role. As income rises, households spend a smaller fraction of their income on heating. At the same time, the amount of heating energy consumed rises with income. In fact, the top income quintile regularly consumes 2-3 times as much heating energy as the bottom one.

The results vary between Member States: it clearly shows that eastern European countries (region NE = -1.4%, region SE = -0.9%) benefit much more from the measures in the HIGH-I scenario (compared to the baseline and due to a reduction in heat and energy expenditure). This can be due to the fact that the share of worst performing buildings and therefore energy expenditure is higher. The majority of the population in eastern Europe own and live in single-family houses. The share is significantly higher than in western European countries.

Figure 6.11 shows the difference in energy expenditure between the HIGH-I scenario and the baseline in absolute terms. Following our assumption that renovation and subsequent energy savings are distributed proportionally to expenditure shares, low-income households in the first quintile save around 92 PPP[160] in 2030 and 284 PPP in 2050. High-income households in the fifth quintile save around 202 PPP in 2030 and 624 PPP in 2050. This is due to energy efficiency measures in buildings.

Figure 6.11: Difference between HIGH-I and baseline: heat and electricity expenditure by income quintiles for EU-27 (2030 and 2050)



Source: Guidehouse et al., based on Eurostat (hbs_str_t223) and own calculation

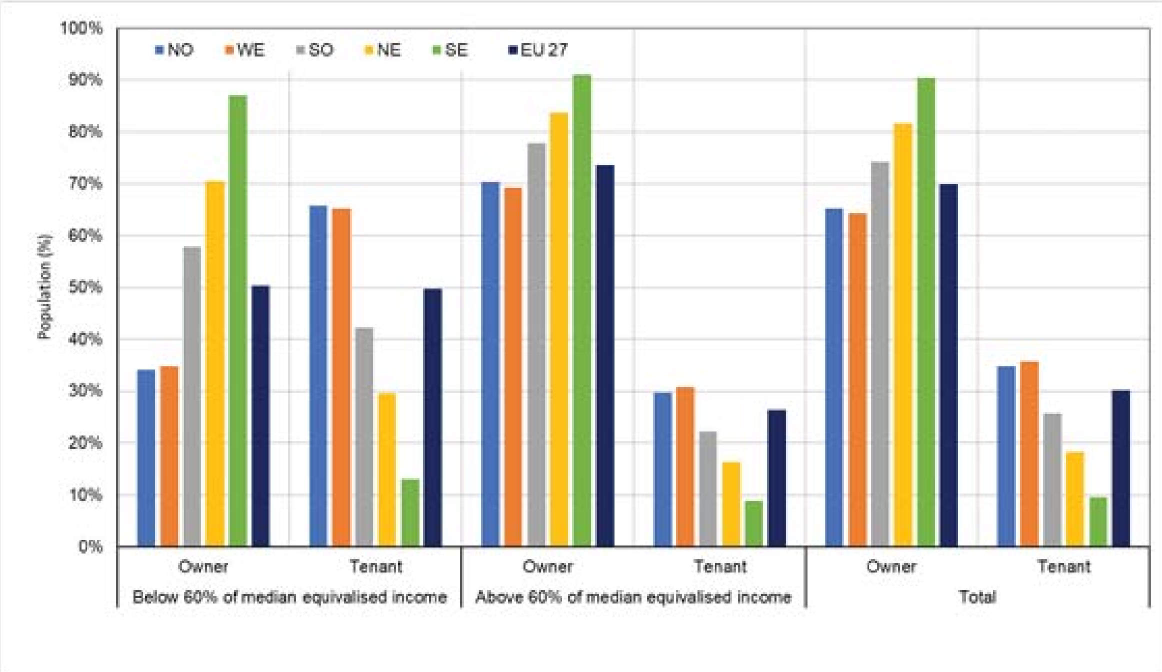
6.4.1.4 Property values and rents

Estimating the impact of energy efficiency on the value of buildings is difficult, as both sale and rental prices are influenced by a multitude of endogenous and exogenous factors (e.g. location), as well as market conditions and general supply-demand balance. There

160 Purchasing power parity.

is, however, some evidence to suggest that higher values are associated with better performance[161]. In addition, buildings with better energy performance have shorter vacancy periods, a lower loss of rental income due to changing tenants and, as such, show a more positive operating impact for the owner. In the commercial sector, buildings that fail to keep up with technological advances, including widespread advances in energy efficiency, risk becoming obsolete, especially in unfavourable market conditions (such as periods of low or negative economic growth)[162].

Figure 6.12: Distribution of the EU population by tenure status, region and income group in 2019[163]



Source: Guidehouse et al., based on Eurostat (hbs_str_t223) and own calculation

We can therefore assume that an indirect effect of the implementation of MEPS on the value of upgraded buildings would be positive. At the same time, worst performing buildings needing renovation to comply with MEPS could be penalised in market transactions by 'brown discounts', which could lead to their depreciation or even stranded assets.

[161] Zancanella et al. (2018) explain that energy efficiency measures increase the price of residential assets by around 3-8%, with an increase of around 3-5% in residential rents compared to similar properties (https://link.springer.com/article/10.1007/s11146-019-09720-0) . The values vary across regions and countries, as well as due to different property types (e.g. apartments vs. houses). Chegut et al. (2019) show the high variation in energy efficiency values on European housing markets; they find ranges between 0.04% and 15%, depending on the market and transaction type. Chegut et al. (2020): Energy Efficiency Information and Valuation Practices in Rental Housing; https://link.springer.com/article/10.1007/s11146-019-09720-0/tables/6

[162] The Macroeconomic and Other Benefits of Energy Efficiency (europa.eu)

[163] Guidehouse (2021) based on Eurostat (ilc_lvho02).

In turn, MEPS could result in an increase in rents for those buildings that are renovated in compliance with minimum energy performance standards. To cover their investment costs, landlords tend to pass on energy efficiency-related investment costs to tenants by increasing rents. Depending on the extent of the rent increase, this might counterbalance any savings that tenants might experience through lower energy costs[164]. This effect is expected to be variable across countries and income groups as illustrated in Figure 6.12, which shows the variable share of tenancy across the EU.

Aligning the incentives in the rental housing market with efficient climate protection is most important in Germany, Austria, the Netherlands, France, Sweden and Denmark, where more than 30% of households are renters. The effect of higher rents is also expected to be regressive, as tenancy is higher in populations with below 60% of median equalised income. Appropriate policies and incentives can mitigate the possible increase in rents[165].

6.4.2 Macroeconomic impacts

6.4.2.1 Employment and value added

Table 6.7: Summary of key macroeconomic impacts[166]

		2030				2050			
Main indicator	[unit]	LOW	MOD.	HIGH-I	HIGH-II	LOW	MOD.	HIGH-I	HIGH-II
Macro-economic impact									
Additional low and medium skilled jobs	[% from 2020]	0.22%	0.27%	1.24%	1.29%	0.16%	0.13%	1.18%	1.17%
Additional high skilled jobs	[% from 2020]	0.14%	0.18%	0.63%	0.65%	0.12%	0.10%	0.65%	0.66%
Additional value-added created in the EU	[% from 2020]	0.18%	0.24%	0.86%	0.91%	0.15%	0.13%	0.85%	0.86%

Source: Guidehouse et al.

The EU construction industry ecosystem contributes around 9.6% of EU value added and employs almost 25 million people in 5.3 million firms[167]. It consists of contractors for building and infrastructure projects, some construction product manufacturers[168], engineering and architectural services as well as a range of other economic activities such as rental and leasing of machinery and equipment and employment agencies.

Higher renovation rates and higher standards for new constructions will have a multiplier effect on jobs and growth in the construction sector and across the **renovation value chains**. The construction ecosystem is labour-intensive, and over 99% of its firms are

[164] Where the rent includes costs for heating and domestic hot water, the situation is different as the landlord makes the investment and also benefits from the savings.
[165] Renonbill (2021): The Renovation Wave: building renovations to foster EU economic recovery. Policy briefing.
[166] Results of the Exiobase modelling, reflecting changes in jobs and value-added induced by changes of domestic production due to investment impulse on affected sectors.
[167] SWD(2021) 351 final.
[168] Some categories of products that are essential to construction, such as cement, glass, ceramics and tiles, and plastic pipes are covered under the energy-intensive industries ecosystem.

micro businesses or **small and medium-sized enterprises (SMEs)**[169]. They supply essential technologies, materials and services locally[170].

The effects on **employment** and valued added are the economic effects that result from increased investments in building renovation and reduced energy consumption of fossil fuels for heating. These effects can be considered net effects as they account for simultaneous changes due to investment in renovation and a subsequent reduction in energy demand.

However, the expected positive impact is dependent on the availability of financial resources. If financing is not available, the additional expenditure diverts productive resources (either capital or labour) from other productive uses. Such crowding out results in scarcity conditions that have adverse effects on the economy[171]. In addition, budgetary effects (when the funding of energy efficiency expenditure reduces other expenditure to the detriment of private consumption and productive investment) can also reduce the positive impact of energy efficiency spending.

In the HIGH scenarios, the need for **low- and medium-skilled labour**[172] increases significantly, while the reduction in fossil fuel energy demand leads to reduced employment and value added in those sectors that supply fossil fuels for heating, in particular natural gas followed by heating oil and district heating, and also to a smaller extent coal. At the same time, additional employment is needed to provide electricity used in heat pumps. New electricity demand is assumed to be based on renewable electricity, e.g. solar PV, wind and biomass-based electricity. In the HIGH I scenario, a total of around 1.4 million additional low- and medium-skilled jobs will be created by 2030 compared to 2020. These additional jobs will be kept at almost the same level in 2050 compared to 2020 (Table 6.7). Another 450,000 additional jobs will be created in the high-skilled segment. For high-skilled labour, the share of additional employment is highest in the trade & services and construction sectors. This reflects the jobs of architects, real estate, logistics, financial services and several other professions in the construction sector, which are key to renovations. Renovation and new build activities within the EU also further stimulate employment in countries that supply products and services to the EU[173].

---

[169] SWD(2021) 351 final.

[170] Only companies in the chemicals, rubber and plastic product sectors are likely not to be small or medium-sized.

[171] The analysis underpinning the Climate Target Plan and the EED revision estimated that around 9-20 jobs in manufacturing and construction are created for every USD 1 million invested in retrofits or efficiency measures in new builds in the EU.

[172] The need for additional low- and medium-skilled labour is highest in the construction and material sector, including on-site construction activities, but also glass production for windows, chemicals, rubber, and plastics to provide insulation material, wood for window frames and new construction.

[173] Such employment effects are seen mainly in the Asia and Pacific regions for low- and medium-skilled labour, and to a smaller extent also in other non-EU countries (including the UK, Norway, Iceland etc.) and

Effects on **value added**[174] follow a similar pattern to employment effects and are dominated by stimulus in the construction and material sector through investment in insulation, window renovation and new build (Table 6.7). Trade and services also play a major role. They include installation of machinery and equipment, e.g. heating technologies (boilers, heat pumps, pipes, radiators etc.) but also architects, contracting, real estate activities, renting of machinery and equipment, logistics, transport services, and delivery. The service sector, which consists almost entirely of SMEs, is traditionally heavily involved in the building environment. The effects are almost constant over 2030-2050.

The main positive stimulus can be seen for the construction and material sectors as well as machinery and equipment. This is due to their important role in providing goods and services for wall/floor/roof insulation, windows and heating replacements as described above. A reduction in energy demand only has small negative effects on value added, in particular in the sectors that provide fossil fuels for heating, i.e. natural gas, heating oil and coal. Overall, EU value added in the HIGH-I and HIGH-II scenarios is around +0.9% (or around EUR 115-125 billion additional value added) higher than in 2020 both in 2030 and 2050, while in LOW/MODERATE it is around +0.2-0.25% in 2030 and +0.11-0.14% in 2030 and 2050 respectively (Table 6.7).

6.4.2.2 The challenges of increasing labour

Delays in the construction sector experienced since the beginning of the pandemic call for an analysis of whether the economy can adapt to higher demand on workforce and skills[175]. In September 2021, almost one third (29.7%) of the firms in the construction sector in the EU-27 declared that a shortage of labour is a factor limiting building activity[176]. The average proportion in 2018-2019 was 23.7%, up from 13.2% in 2016-2017 and 6.6% in 2014-2015, showing a clear increase over a five-year period.

We first need to analyse the impact of the measures proposed under the 'Fit for 55' package overall and of the EPBD revision specifically on the availability of labour. On the impact of the 'Fit for 55' package, methods used include a dynamic analysis using the general equilibrium model GEM-E3-FIT. It takes into consideration direct as well as indirect and induced effects on both the demand and supply of labour, also in other

---

in Africa. High-skilled labour effects in other regions induced by EU-27 activities occur to a smaller extent also in Asia-Pacific as well as in the rest of Europe. While employment effects in Asia-Pacific and the rest of Europe refer mainly to industry and trade & services that get delivered to the EU-27 (e.g. insulation materials), for Africa they are highest in the agricultural and forestry sector.

[174] The main difference between GDP and gross value added is that the gross value added of a sector is measured net of taxes (for instance VAT) and subsidies on products. In the national accounts for the euro area, product taxes (minus subsidies) are recorded for the economy as a whole and added to the total gross value added.

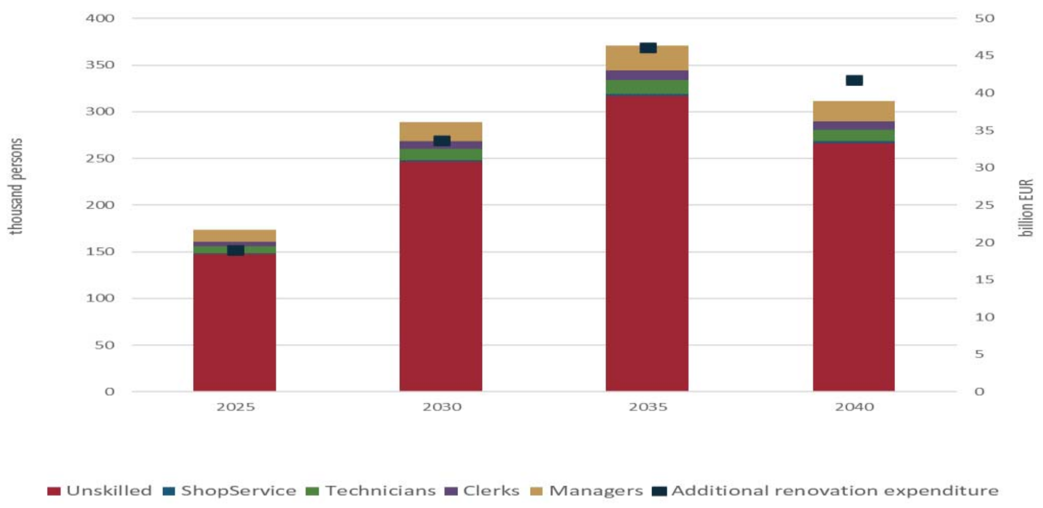
[175] No conclusive data was found on the extent (quantification) of those delays.

[176] Eurostat monthly data from the Business Survey. No conclusive data was found on the extent (quantification) of those delays.

sectors affected by activity in the construction sector. The GEM-E3-FIT model is described in the impact assessment of the 'Fit for 55' package[177].

Figure 6.13 shows the additional demand for labour by occupation type in the MIX scenario compared to REF.

Figure 6.13: Renovation expenditure and additional demand for labour by occupation type in the EU (MIX vs REF).



Source: analysis based on GEM-E3-FIT input-output tables.

To put these changes into perspective, we can compare the values reported in Figure 6.13 to the year-to-year variations of employment in the construction sector as shown in Table 6.8.

Table 6.8: Employment in the construction sector in the EU

	2011	2012	2013	2014	2015	2016	2017	2018
Employment in construction [m people]	11.78	11.46	10.96	11.19	10.97	11.29	11.53	12.14
Change year-to-year [m people]	-	-0.319	-0.498	0.232	-0.217	0.321	0.240	0.608
Change year-to-year [%]	-	-2.7%	-4.3%	2.1%	-1.9%	2.9%	2.1%	5.3%

Source: Eurostat SBS.

177 For example in the annexes of the EED impact assessment SWD(2021) 623 final, Part 2. The setup for the model is similar to the scenarios used to estimate the macroeconomic impact of the Climate Target Plan or the 'Fit for 55' policy initiatives.

The additional demand for labour in the construction sector by 2030 due to the 'FIT for 55' package appears to be smaller (or at most comparable to) than the year-to-year variations in employment. Moreover, the figures from Table 6.8 cumulate the effect of all policies and measures in the 'Fit for 55' package and therefore constitute an upper bound for the impact of the EPBD.

To understand the likely impact of the EPBD revision alone on labour supply, we performed a sensitivity analysis on investments in construction. To find a meaningful range for the change in investments, we linked it to the renovation rate, which depends on the implementation of the revised EPBD. The renovation rate in the residential sector is 1.2% of the building stock per year in the REF scenario and 2.1% in the MIX scenario[178]. The renovation rate could be lowered by 0.6 percentage points without the drivers provided by the EPBD revision. A range of +-0.6% was therefore chosen for the sensitivity analysis, corresponding to renovation rates of 1.5% and 2.7%. This corresponds to a change in investments of +-29% (using the split of investments between renovation and new buildings provided by the PRIMES model).

This investment shock was introduced in the GEM-E3-FIT model. Table 6.9 shows the % change in construction activity and employment. A +-29% change in expenditure on the renovation of old constructions results in approximately a 1% change in construction activity and employment (changes in total employment are negligible[179]).

Table 6.9: Change (in %) due to a +-29% change in expenditure on renovation of old constructions.

	MIX rel. to REF			MIX_minus29% rel. to MIX			MIX_plus29% rel. to MIX		
	2025	2030	2035	2025	2030	2035	2025	2030	2035
Construction activity	1,05	1,25	0,24	-1,02	-0,99	-0,84	1,02	0,98	0,84
Total Employment	0,03	0,01	-0,06	-0,04	-0,03	-0,03	0,03	0,03	0,03
Construction employment	1,27	1,58	0,89	-1,00	-0,95	-0,80	1,00	0,95	0,79
Gross earnings_Total	0,00	0,00	-0,01	-0,02	-0,02	-0,02	0,02	0,02	0,01
Gross earnings_Unskilled	0,06	0,02	-0,14	-0,13	-0,13	-0,11	0,13	0,13	0,11
Gross earnings_ShopService	-0,03	-0,03	0,01	0,03	0,03	0,02	-0,03	-0,03	-0,02
Gross earnings_Technicians	-0,03	-0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Gross earnings_Clerks	-0,01	0,01	0,03	0,00	0,00	0,00	0,00	0,00	0,00
Gross earnings_Managers	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00

Source: GEM-E3 based on Eurostat

This 1% change is substantially and logically below the change to the impact of the 'Fit for 55 Package' overall. As explained above, this is itself in line with or even below the rates of job creation in the construction sector recorded in recent years. According to Eurostat, employment in the construction sector remains well below the peak reached in the late 2000s: 12.6 million employees (6.7% of total employment) in Q1-2021 vs. 16.1 million employees (8.4% of total employment) in Q3-2008. Those historical trends and fluctuations indicate that the construction sector is probably able to further absorb the

[178] Since the only goal is to define a range for investments, for simplicity reasons only the renovation rate in the residential sector was used.

[179] Due to the rest of the impacts via the readjustment of wages, interest rates etc. as explained in the Climate Target Plan impact assessment and under fairly pessimistic assumptions on the availability of capital and labour.

estimated additional jobs that will be needed. The revised EPBD could contribute to a sector severely hit after the 2008 crisis.

This capacity of the construction market to adapt to higher demand should be supported by the fact that the EU-27 is not at full employment at aggregate level. Cross-sectoral shifts and cross-border migration (i.e. from countries with an excess of unemployed workers to those with a deficit) will also help ease potential shortages linked to higher demand for works. Demand in the construction sector is mostly for unskilled jobs, but pressure in this labour market is mitigated by the decline of unskilled employment in other sectors.

Those elements nonetheless have to be considered with care. As shown in the rates of job creation and destruction, the construction sector is particularly cyclical since it depends not only on business and consumer confidence, but also macroeconomic factors such as interest rates linked to central banks' monetary policies and to governments' budgetary programmes. It is therefore not immune to temporary shocks, which may lead to delays and temporary price increases similar to those recorded since the beginning of the pandemic. The lack of even a small number of critical workers in key sectors could also result in significant disruptions.

While those shocks and potential disruptions cannot be fully anticipated, an appropriate package of policies and mechanisms can limit their occurrence and impact. Those responses, including Commission initiatives, are presented in Chapter 8.

6.4.3 Impacts on energy poverty

A fair transition is central to the EU Green Deal. The CTP impact assessment showed that, in the absence of mitigating measures, climate policies could have a regressive impact that negatively affects vulnerable consumers. Policy intervention in the building sector has the potential to mitigate or even reverse this effect, especially with regards to energy poverty[180] and its linkage to poor energy efficiency of homes. The Commission Recommendation on energy poverty[181] highlights the need to address building performance, the fair distribution of burdens and energy poverty simultaneously to ensure clean energy for all Europeans[182].

[180] Caldeira, Igor; Dallhammer, Erich; Schuh, Bernd; Hsiung, Chien-Hui (2019): Energy Poverty. Territorial Impact Assessment. European Committee of the Regions: Commission for the Environment, Climate Change and Energy (ENVE).

[181] Commission Recommendation of 14.10.2020 on energy poverty (SWD(2020)960final) https://ec.europa.eu/energy/sites/ener/files/recommendation_on_energy_poverty_c2020_9600.pdf together with its annex and accompanying staff working document.

[182] According to the Commission Recommendation on energy poverty and Regulation (EU) 2018/1999 and its recast 2019/944/EU, 'energy poverty' means a situation in which households cannot afford the essential energy services necessary for a decent standard of living.

Table 6.10: Summary of main socio-economic impact at EU level in the considered scenario (compared to baseline)

		2030				2050			
Main indicator	[unit]	LOW	MOD.	HIGH-I	HIGH-II	LOW	MOD.	HIGH-I	HIGH-II
Social impact									
Household expenditure									
Share of heating expenditure in total expenditure									
Quintile 1	[% from 2020]	-0.1%	-0.1%	-0.4%	-0.5%	-0.5%	-0.5%	-1.3%	-1.4%
Quintile 2	[% from 2020]	-0.1%	-0.1%	-0.4%	-0.4%	-0.4%	-0.5%	-1.2%	-1.2%
Quintile 3	[% from 2020]	-0.1%	-0.1%	-0.4%	-0.4%	-0.4%	-0.4%	-1.1%	-1.1%
Quintile 4	[% from 2020]	-0.1%	-0.1%	-0.3%	-0.4%	-0.4%	-0.4%	-1.0%	-1.0%
Quintile 5	[% from 2020]	0.0%	-0.1%	-0.3%	-0.3%	-0.3%	-0.3%	-0.8%	-0.9%
Share of electricity expenditure in total expenditure									
Quintile 1	[% from 2020]	-0.1%	-0.1%	-0.4%	-0.4%	-0.5%	-0.5%	-1.2%	-1.3%
Quintile 2	[% from 2020]	-0.1%	-0.1%	-0.4%	-0.4%	-0.4%	-0.4%	-1.1%	-1.1%
Quintile 3	[% from 2020]	-0.1%	-0.1%	-0.3%	-0.4%	-0.4%	-0.4%	-1.0%	-1.0%
Quintile 4	[% from 2020]	-0.1%	-0.1%	-0.3%	-0.3%	-0.3%	-0.4%	-0.9%	-0.9%
Quintile 5	[% from 2020]	0.0%	-0.1%	-0.2%	-0.3%	-0.3%	-0.3%	-0.8%	-0.8%
Energy poverty indicators (mean change across deciles)									
Arrears on utility bills	%points from BS	-0.2%	-0.2%	-1.2%	-1.1%	-1.3%	-1.4%	-3.6%	-3.6%
Inability to keep home adequately war	%points from BS	-0.2%	-0.2%	-1.2%	-1.2%	-1.4%	-1.5%	-3.7%	-3.7%
Low absolute energy expenditure (M/2	%points from BS	-0.3%	-0.3%	-1.6%	-1.5%	-1.8%	-1.9%	-4.8%	-4.9%
High share of energy expenditure in in	%points from BS	-0.3%	-0.4%	-1.7%	-1.7%	-2.0%	-2.1%	-5.3%	-5.4%
Population in a dwelling with a leaking roof, damp, rot frames									
<60% of median eq income	[% from 2020]	-0.4%	-1.0%	-1.2%	-2.0%	-0.6%	-1.4%	-1.8%	-3.0%
>60% of median eq income	[% from 2020]	-0.2%	-0.6%	-0.7%	-1.1%	-0.3%	-0.8%	-1.0%	-1.7%
Total population	[% from 2020]	-0.3%	-0.6%	-0.8%	-1.3%	-0.4%	-0.9%	-1.1%	-1.9%

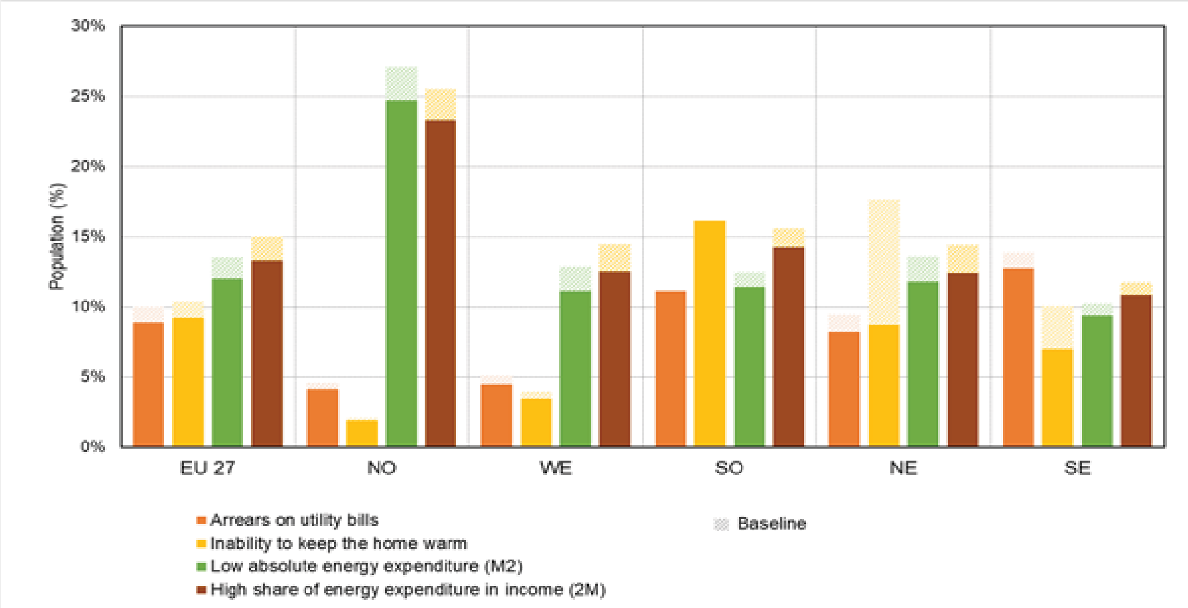
Source: Guidehouse et al.

On average, EU consumers spent 31.9% of their overall consumption on housing[183]. The share spent on housing including water, heat and electricity increases when income decreases, therefore low-income households carry a much higher burden for housing than higher-income households[184]. The EU survey on income and living conditions (EU SILC) estimates that 31 million Europeans (7% of the EU-27 population) were unable to keep their home adequately warm in 2019. This is a reduction of 4 percentage points compared to 2014. A similar number is being reported with regard to arrears on utility bills. Around 6% of the EU-27 population were affected by this in 2019. As assessed in the previous section, all options would reduce heat and electricity expenditure (albeit with different degrees of intensity across scenarios). This is expected to have positive effects on poverty alleviation if combined with appropriate funding schemes.

[183] Eurostat (hbs_str_t211).
[184] This is the case even though actual expenditure for energy (heat and electricity) is much higher for high-income households. In fact, the top income group regularly consumes 2-3 times as much heating energy as the bottom one. This is mainly due to larger floor spaces in houses or apartments as well as more appliances in high-income households.

Compared to the baseline, all scenarios lead to a decrease in the share of population in **energy poverty** for all main energy poverty indicators[185]: arrears on utility bills, inability to keep home warm, the proportion of households whose share of energy expenditure in income is more than twice (2M) the median share or whose absolute energy expenditure is only half of (M/2) the median expenditure (Table 6.10). The impact is highest in the two HIGH scenarios – these deliver more and better renovations, which will reduce energy bills and improve indoor conditions. Lower-income households in particular benefit from the policy measures, notably in the two HIGH scenarios. The relative decrease (compared to the baseline) in energy poverty indicators for the poorest decile and in the mean across all deciles is around 3-4 times higher in 2030 and more than twice in 2050 for HIGH scenarios than in LOW and MODERATE ones. In HIGH scenarios, this affects around 12 million households, whose energy poverty is reduced compared to the baseline. In the HIGH-I scenario, the share of the population in decile 1 unable to keep their homes warm decreases from 22% to 19% in 2030 and to 14% in 2050. In the second decile, the share of the population decreases from 17% to 15% (in 2030) and to 11% (in 2050). The high ambition measures therefore result in a decrease in energy poverty as measured by the indicator 'share of population unable to keep home warm'.

Figure 6.14: Comparison HIGH-I and baseline: share of energy poverty by indicators in population of EU-27 and five European regions (2030)



Source: Guidehouse et al., based on data from the EU Energy Poverty Observatory and Eurostat (EU SILC; Household Budget Survey)

[185] The calculation is based on the assumption that energy savings are proportional to energy expenditure across income groups. The expenditure on energy per disposable income is taken from Eurostat (2021) and the Energy Poverty Observatory (2021).

Figure 6.14 provides a more detailed view of the countries affected by energy poverty. Member States like Bulgaria, Croatia, Hungary, Cyprus and Latvia exhibit high rates of energy poverty according to the indicators 'arrears on utility bills' and 'inability to keep the home warm' in 2030. On the two expenditure indicators (M2 and 2M), Nordic countries are most affected (e.g. Sweden, Finland).

While there are benefits in reduced energy expenditure due to energy efficiency measures, there is also the potential of unrealised energy savings as efficiency gains can be counterbalanced by increased energy consumption. The rebound effect leads to fewer reductions than expected. In particular, households who were previously unable to keep their homes warm might use more heat after the efficiency improvements than before. The extent of such indirect effects driven by higher disposable income cannot be anticipated. However, examples from Sweden, which has a high efficiency renovation rate, show that such effects tend to be small[186].

6.4.4 Financing, affordability and distributional impacts across EU regions: a sensitivity analysis

As shown above, investments in HIGH scenarios are much higher than in the baseline or in the LOW or MODERATE ambition scenarios. Additional investments in renovation combined with heating and cooling technology is around four times higher in HIGH scenarios.

Investments can be recovered through energy savings. However, if buildings are not owner-occupied, energy costs are usually paid by tenants. To cover their investment costs, landlords then tend to pass on energy efficiency-related investment costs to tenants by increasing rents. Depending on the extent of the rent increase, this might counterbalance any savings that tenants might experience through lower energy costs, thereby placing an additional burden on households. Therefore, distributional impacts for tenants depend largely on whether and in how far renovation costs can be passed on and whether they exceed savings in energy costs. The possibility to increase rents is regulated in different ways across Member States[187]. As low-income households spend the highest share of income on housing-related costs, they are most vulnerable to any increase in rent, which is not balanced out by energy savings.

Many stakeholders, in particular non-governmental organisations and professional associations, expressed concern about the lack of access to affordable and sustainable energy for all EU citizens. They also stressed the importance of the EPBD revision to tackle energy poverty and vulnerable households in general. The rental market is dominated by the split incentives (or principal agent) dilemma of investing in the energy renovation of buildings. More precisely, tenants have no incentive to invest in a building

[186] Agora (2019).
[187] Castellazzi 2017: Overcoming the split incentive barrier in the building sector.

owned by others, and building owners lack incentives to undertake renovation efforts – tenants are largely responsible for paying energy costs, so they cannot reap the benefits of reduced energy consumption. This non-economic barrier is more prominent in countries from northern and western European regions where the rental market prevails and a lower share of the population own homes (Figure 6.12).

To recover the investment costs, building owners tend to pass on energy efficiency-related investment costs to tenants by increasing rents. Depending on the extent of the rent increase, this might not counterbalance the savings that tenants might experience through lower energy costs, thereby placing an additional burden on households. Therefore, economic impacts for tenants greatly depend on whether and in how far renovation costs can be passed on and whether they are above or below the cost energy savings. As low-income households spend the highest share of income on housing-related costs, they are most vulnerable to any increase in rent that is not sufficiently compensated by energy savings as reflected in the energy bills. For this reason, a rent increase can generate regressive impacts.

To better assess the distributional impact of renovations across income classes and tenure status (owners and tenants), a sensitivity analysis was performed. The impact of two types of renovation was simulated – one in which buildings are renovated to zero-emission level, and the other one to partial zero-emission level. The analysis was applied to two representative residential buildings – a single-family house and a building unit in a multi-family block of flats, transposed to the most representative country from each EU climate zone in question (Table 6.11).

Table 6.11: Reference conditions for the sensitivity analysis of distributional impact of renovation on low-income households

	Tenant Households 1	Owner Households 2
Climate zone	NO, WE, SO, NE, SE	NO, WE, SO, NE, SE
Selected Member States	DK, DE, CY, CZ, SK	FI, BE, ES, SI, SK
House type	Apartment in MFH	SFH
Time-frame	average year (2020-2050)	average year (2020-2050)
Discount rate	6%, over 30 yrs	6%, over 30 yrs
Floor area	75 m²	130 m²
Status	Tenant	Owner

Source: Guidehouse et al.

For each zone and type of building, the investment in renovation and the corresponding energy savings were calculated, annualised (present value) over a 30-year period with a 6% discount rate[188]. The annual income of lowest and highest quintile were also

[188] 6% is the average discount rate used in Member State cost-optimality reports for the 'micro-perspective'.

estimated as well the approximate share of tenure for households below and above 60% of the median equivalised income (i.e. below and above at risk of poverty).

Second, the sensitivity analysis was performed based on 3 scenarios. These represent different possibilities related to the financial support available to owners or to the passing on of investment costs to tenants (Table 6.12).

Table 6.12: Scenarios for the sensitivity analysis

	Owner	Tenant
Scenario 1	No additional support for the investment	All investment cost passed onto the tenant
Scenario 2	25% grant support for investment	75% of investment cost passed onto the tenant
Scenario 3	40% grant support for investment	60% of investment cost passed onto the tenant

Source: Guidehouse et al.

Tables 6.13 and 6.14 present a summary of the results for ZEB and partial-ZEB renovation on each of the two reference buildings and in all three scenarios. Annex D presents a more extensive version of the sensitivity analysis.

In the case of a low-income household living in a rented apartment in a multi-family building that undergoes a ZEB-level renovation, the energy savings as a share of the annual income of low-income households vary from 7.9% in the NE region to 4.4% in the NO region. The sensitivity analysis shows significantly different impacts depending on the share of investment costs compensated by higher rents. When the full investment (annualised) is passed onto the tenant (scenario 1), then the rent increase does not compensate for the reduction in energy expenditure in all regions. The exception is in the NE region, where the reduction in energy costs generated by the energy savings overcompensates for the increase in rent due to the investment. When 75% of the annualised investment costs are passed onto the tenant (scenario 2), there is a positive economic impact (the savings on energy bills compensate for higher rents) in all regions except for inthe NO region. If only 40% of the annualised investment is passed onto the tenant, then there is a positive impact on the rent in all regions since the energy cost reductions generated by the renovation overcompensate for the impact of investment.

This example therefore shows that even with more costly renovations, it is possible that with split incentives, well-designed rules on rent increases, which take into account the impacts on energy savings, can result in win-win solutions for the owners and tenants, or limited net economic impacts for tenants. However, this can be difficult or limited to some regions. Financial assistance to the building owner to cover partial investment costs ensures that win-win situations could be achieved more easily. These results are also sensitive to energy prices. If there is a carbon price on heating fuels, the payback periods shorten and the net economic impact for the tenant becomes larger.

Table 6.13: Impact of renovation on low-income households living in multi-family houses (tenant)

Multi-familiy house (MFH) unit, average floor area of 75m2, inhabited by a tenant, initial status: not renovated

EU Region	ZEB renovation					partial ZEB renovation				
	Investment per MFH unit	Energy savings	Scenario 1 full pass on tenant	Scenario 2 75% pass on tenant	Scenario 3 40% pass on tenant	Investment per MFH unit	Energy savings	Scenario 1 full pass on tenant	Scenario 2 75% pass on tenant	Scenario 3 40% pass on tenant
		low income household	Net Effect on low income HH (Rent increase minus energy savings)				*low income household*	Net Effect on low income HH (Rent increase minus energy savings)		
	Euro	*(% of income)*	*(% of income)*	*(% of income)*	*(% of income)*	*Euro*	*(% of income)*	*(% of income)*	*(% of income)*	*(% of income)*
NO	19,654 €	4.4%	2.3%	0.6%	-1.7%	4,323 €	0.2%	1.2%	0.9%	0.3%
WE	18,718 €	7.8%	0.9%	-1.3%	-4.3%	4,045 €	0.7%	1.2%	0.7%	0.0%
SO	9,160 €	5.2%	1.2%	-0.4%	-2.6%	909 €	0.2%	0.4%	0.3%	0.1%
NE	7,476 €	7.9%	-0.3%	-2.2%	-4.8%	759 €	0.5%	0.3%	0.1%	-0.2%
SE	5,706 €	7.2%	0.1%	-1.8%	-4.3%	785 €	0.7%	0.3%	0.0%	-0.3%

Source: Guidehouse et al.

If the same apartment undergoes only a partial ZEB renovation, this will generate a rental increase in all regions and all scenarios except for NE and SE regions in scenario 3, where only 40% of the annualised investment is passed onto the tenant. This example shows that with renovation that achieves lower savings, even in cases where two thirds of the investment costs are passed on through a rent increase, it is likely that the net economic impact will be rather small or that the extra costs will be compensated. However, compared to the first example, there are net benefits for the tenant only if lower costs are passed on, and the upfront investment is considerably higher.

The case of an owner-occupied apartment is similar to the rented apartment case above[189].

If a low-income household living in their own single-family house undertakes a ZEB-level renovation, the energy savings generated as a share of annual income are higher than in an apartment, varying from around 16% in NO, WE and SO regions to around 27% and 40% in SE and NE regions respectively. The analysis shows that when there is no financial support for investment and the full cost of renovation is paid by the owner (scenario 1), then the housing costs increase in all regions. The exception is in the NE and SE regions, where the reduction in energy costs generated by the energy savings overcompensate for the investment costs. With a 25% investment grant (scenario 2), there is a positive impact on the housing costs in all regions except for in the NO region.

[189] In the case of an owner-occupied apartment in a multi-family building, the scenarios will be such: scenario 1 with no investment grant, scenario 2 with 25% investment grant and scenario 3 with 60% investment grant.

With an investment grant of 60%, there is a positive impact across regions since the energy cost reductions generated by the renovation overcompensate for the impact of investment. Thanks to the significant reductions in energy bills, the investment costs do pay off in some of the regions even without investment support, and in almost all regions with 25% support.

Table 6.14: Impact of renovation on low-income households living in single-family houses

Single-familiy house (SFH), average floor area of 130m2, inhabited by the owner, initial status: not renovated.

EU Region	ZEB renovation					partial ZEB renovation				
	Investment per MFH unit	Energy savings	Scenario 1 no invest. support	Scenario 2 25% invest support	Scenario 3 60% invest support	Investment per MFH unit	Energy savings	Scenario 1 no invest. support	Scenario 2 25% invest support	Scenario 3 60% invest support
		low income household	Net Effect - Housing cost increase minus energy savings (% of income)				low income household	Net Effect - Housing cost increase minus energy savings (% of income)		
	Euro	*(% of income)*	*low income HH*	*low income HH*	*low income HH*	*Euro*	*(% of income)*	*low income HH*	*low income HH*	*low income HH*
NO	56,587 €	15.8%	8.1%	2.1%	-6.3%	20,057 €	1.9%	6.6%	4.5%	1.5%
WE	39,889 €	16.2%	1.7%	-2.8%	-9.1%	10,561 €	3.1%	1.6%	0.4%	-1.2%
SO	22,675 €	16.3%	2.3%	-2.3%	-8.8%	4,467 €	1.3%	2.4%	1.4%	0.2%
NE	34,533 €	26.6%	-1.4%	-7.7%	-16.5%	11,179 €	3.5%	4.7%	2.6%	-0.3%
SE	26,051 €	40.0%	-7.0%	-15.2%	-26.8%	7,968 €	8.5%	1.6%	-1.0%	-4.5%

Source: Guidehouse et al.

If the same single-family house undergoes only a partial ZEB renovation, then the energy savings generated as a share of annual income are consistently lower, i.e. from around 8.5% in the SE region to around 1.9% in the NE region and 1.3-3.5% in the other regions. In this case, the net economic impact on housing costs is positive only for the SE region with 25% investment support (scenario 2) and for WE, NE and SE regions in scenario 3 with a 60% investment grant (scenario 3). Compared to the previous example, repayment is therefore more difficult, but the net impact is also much smaller.

Based on the above case studies, we can draw several conclusions:

- ZEB renovations are more costly than partial ZEB renovations, but the associated energy and cost savings are also higher (across all EU zones and scenarios). Therefore, the net impact on the housing budgets of low-income households is consistently smaller for ZEB renovations.
- The negative impact on the housing budgets of low-income households can be mitigated by additional financial schemes with preferential loans adjusted appropriately to the payback period of the renovation measure.
- Well-designed rules on rent increases that take into account the impacts on energy savings result in win-win solutions for owners and tenants.

- Although the upfront investment is higher for ZEB renovations than for partial ZEB renovations, the benefits are higher in the former. The measure also leads to more consistent savings that have the potential to alleviate energy poverty. Partial ZEB (medium) renovations may be cheaper, but even a high level of subsidies for the upfront investment in some EU regions will not fully mitigate the negative impact on the energy expenditure of low-income households.

6.4.5 Further considerations regarding the impacts of MEPS at Member State level

The effects of the policy options could vary across EU countries for multiple reasons. Some of these are structural, while others can be mitigated by proper policy design. The following circumstances play a role:

- the existing conditions and energy performance of the building stock;
- climatic conditions[190];
- calculation of energy classes in national EPC schemes;
- ownership structure and dynamics of the housing markets.

These aspects are described in Annex F, Section 7.2.

6.5 Impacts of e-mobility options.

The impacts are presented in Annex I.

7. How do the options compare?

In this Chapter, the policy options presented in Chapter 5 and assessed in Chapter 6 are compared from several angles in line with the better regulation criteria of effectiveness, efficiency, coherence, administrative burden, subsidiarity and proportionality.

- Effectiveness: assessment of the extent to which proposed options would achieve the specific objectives of this impact assessment as presented in Section 4.1.
- Efficiency and impacts: assessment of benefits versus the costs, taking into account the quantitative assessment presented in Chapter 6 and based on qualitative assessments for the measures related to information and planning tools.

[190] This could be expressed for instance in heating and cooling degree days.

- Coherence: assessment of the coherence of each option with the overarching objectives and other EU policies, focusing on the policies proposed in the 'Delivering the European Green Deal' package.

- Administrative burden and compliance costs: assessment of the cost and additional burden due to the increased ambition (the analysis is included in Annex L).

- Subsidiarity and proportionality: assessment of how the measures comply with the subsidiarity principle and if they necessary to meet the objectives.

7.1 Comparison of options

Effectiveness

Option 1 offers the lowest level of impact with modest GHG emission reductions, mainly because of the narrow scope for mandatory energy performance standards. Furthermore, Member States' voluntary implementation of the BRP does not sufficiently encourage renovation depth, nor does it significantly increase the renovation rate.

Option 2 offers modest additional final energy savings and related GHG emission reductions compared to option 1 by including all non-residential buildings above a certain size, e.g. 1000 m2 by adding MEPS3. A significant leap can be observed between options 2 and 3. The key element of option 3 is the addition of MEPS2, which goes far beyond and includes standards to be set at national level to all residential and non-residential buildings with differentiated schedules to move towards ZEB level. It also includes mandatory BRP for selected building types and strengthened information tools, underpinning MEPS2 and reducing lost opportunities in addressing the energy saving potentials of buildings renovation.

Finally option 4 adds MEPS4 requiring best in class replacements for technical building systems, mainly heat generators. This leads to additional energy and GHG savings, yet does not speed up replacements of boilers.

Table 7.1: Weighted average of the policy options impacts (ref. Table 6.1)

	Option 1: LOW	Option 2: MODERATE	Option 3: HIGH-I	Option 4: HIGH-II
Effectiveness	0	+	++	++
Efficiency	0	0	++	++
Coherence	+	+	++	++
Proportionality	0	0	0	0

Subsidiarity	-	-	-	-

Negative	Slightly negative	No/small positive impact / adequate	Positive	Very positive
- -	-	0	+	+ +

Table 7.2: Comparison of policy packages

Impact in 2030 at EU level	Option 1: LOW	Option 2: MODERATE	Option 3: HIGH-I	Option 4: HIGH-II
Additional final energy savings (vs. BSL)	-2.4%	-3.6%	-11.7%	-16.1%
Additional GHG emission reduction (vs. BSL)	-3.1%	-4.2%	-22.8%	-28.5%
Increase of average renovation rate (vs BSL)	0.2%	0.2%	1.3%	1.3%
Additional investment in buildings envelope and HVAC system (vs. BSL)	EUR 33.2bn/a	EUR 42.3 bn/a	EUR 152 bn/a	EUR 157.3 bn/a
Additional value added creates including in SMEs (vs. 2020 baseline)	EUR 22bn/ 0.18%	EUR 29bn / 0.24%	EUR 104bn / 0.86%	EUR 110bn / 0.91%
Jobs retained or created (vs. 2020 baseline)	332,000	410,000	1. 833 mn	1 .897 mn
Energy poverty: Impact on high share of energy expenditure in income-2M (vs. 2020 baseline)	-0.3%	-0.4%	-1.7%	-1.7%

Source: Guidehouse et al.

As shown in the above Table, the increase of the policy intensity across options (from Low to High) corresponds to greater impacts and a higher contribution to the overall objectives of the revision of the EPBD in terms of reduced GHG, increased energy savings and energy renovations. Overall, the single policy measure that allows a significant increase in the impacts on energy savings, GHG reduction and renewable energy deployment is MEPS2. As illustrated in Chapter 6, the mandatory national measures in MEPS2 significantly extend the scope of application of minimum energy performance standards and therefore substantially increasing the effectiveness of the package of measures in option 3 in comparison to the others. While the EU measures in MEPS1 cover only a fraction of buildings (those being rented or sold and with a low energy class), national standards in MEPS2 will cover progressively all buildings. MEPS1 will be key in addressing the difficulties of split-incentives in renovations, allowing for the worst buildings in the rental market or being purchased to be renovated to medium level, ensuring enough time to carry out the interventions needed. MEPS2 leaves to Member States the flexibility to design MEPS, while framing them in clear decarbonisation pathways defined in national plans Building renovation Plans with clear timelines and intermediate goals and milestones.

Table 7.3: GHG emission and final energy consumption reduction from F55 due to EPBD

EU27 2030 results	F55 gap in the absence of EPBD revision (MIXwoEPBD-MIX)/REF)
CO2 emission in residential sector	-16.4%
CO2 emission in services sector	-11.0%
CO2 emission in residential and services sectors	-14.8%
FEC in residential sector	-6.3%
FEC in services sector	-3.6%
FEC in residential and services sectors	-5.3%

Source: Primes

On the EPBD's expected contribution to the efforts of the 'Fit for 55' package of measures, options 1 and 2 are insufficient, and only in HIGH scenarios the impacts will be commensurate with the impacts assumed in the CTP. Under options 1 and 2, the EPBD revision will fail to substantially contribute to a doubling of the annual rate of renovations. While the average renovation rate in the baseline scenario increases by 0.3% by 2030, the additional renovation rates increase in LOW (option 1) and MODERATE (option 2) scenario is of 0.2% as MEPS apply only to a limited fraction of the building stock. At the same time, the relative increase of renovation rates in the two HIGH scenarios (option 3 and 4) as compared to baseline is 1.3%, notably due to the extension of MEPS measures to all worst performing buildings from the building stock.

GHG emissions in comparison to the baseline will be reduced by only 3.1% and 4.1% in LOW (option 1) and MODERATE (option 2) respectively in 2030 in comparison to the baseline, while in HIGH scenarios (options 3 and 4) the reductions could increase up to 23%. Only these latter levels are considered commensurate with sufficiently contributing to the 'Fit for 55' package of measures. By comparison, in the counterfactual MIXwoEPBD scenario (see Section 6.2), the reductions to be achieved thanks to a strengthened EPBD were considered to be of an order of magnitude of 15% (residential and services sectors).

Similar considerations can be applied to the reductions achieved in final energy consumption as final energy consumption in LOW (option 1) and MODERATE (option 2) will be reduced only by 2.4 – 3.6% by 2030 respectively, which as a contribution is considered too low. The reductions of final energy consumption achieves -11.4 –11.7% in the HIGH scenarios (option 3 and 4). By comparison, in the counterfactual MIXwoEPBD scenario, the reductions to be achieved by 2030 in comparison to the baseline thanks to a strengthened EPBD were considered to be of an order of magnitude of 5.3% (residential and services sectors).

Options 1 and 2 are therefore failing to achieve the first key objective of this initiative of 'Contributing to reducing buildings' greenhouse gas emissions and final energy consumption by 2030, to a level commensurate to the Climate Target Plan goals.' Only options 3 and 4 score high on effectiveness as their impacts are comparable to those expected from the EPBD revision. This assessment is based on the order of magnitude of the efforts as a clear numerical equivalence between the estimate of the contribution of the EPBD revision, and the assessment of impacts of the policy options is not possible due to the different methodological approaches of the two analysis (system-wide, top-down assessment in the Climate Target Plan; versus sectoral, bottom-up in this impact assessment).

Options 3 and 4 will also reduce GHG at a level compatible with climate neutrality by 2050 (second key objective of providing a long-term vision and ensuring that buildings make an sufficient contribution to achieving climate neutrality in 2050), while under option 1 and 2 emissions in the buildings sector by mid-century will still be significant. However, a (-) is attributed to option 4 as MEPS4 could lead to suboptimal renovations in some circumstances as regards the depth of renovation achieved.

Introducing a definition of 'zero emissions buildings' (ZEB) is expected to contribute to the overall goals of reducing GHG, increased energy savings and deployment of renewables in the building sector. ZEBs will also ensure avoiding lock-ins in new constructions, ensuring that they will be '2050 ready' and therefore in line with the long-term decarbonisation objective. The experience of NZEBs shows that the effectiveness of standards and definition could be limited if benchmarks and clear requirements are not set at EU level. Applying ZEBs following a similar process than NZEBs (as in ZEB1) does not therefore seem to guarantee an effective achievement of the goals. ZEB2 and ZEB3 provide for a more effective framework also addressing emissions across the life-cycle of the building (ZEB3).

The information and planning tools (BRP, DEEP, EPC, LTRS) only in the more ambitious options 3 and 4 will ensure the establishment of an adequate supporting framework, enabling to overcome the existing weaknesses and providing consumers reliable and comparable tools. In particular, BRP3 drives staged renovations, in synergies with MEPS and the establishment of a deep renovation definition under DEEP2 which ensure the strongest links with financial instruments. More reliable and similar ratings achieved thanks to EPCQ3 ensure higher market acceptance and comparable efforts and are therefore preferable to softer approaches in EPCQ2 and EPCQ1. LTRS updates and impacts monitoring as in LTRS3 become essential in view of the establishment of national minimum energy performance requirements, while the other options do not guarantee an adequate update of the current provisions.

As regards the strengthening of EPCs, it is expected that only by requiring mandatory additional information on carbon emissions and other indicators (as in EPCSI2 and EPCSI3) EPC would be able to play a role in properly informing and orientating markets towards the decarbonisation of buildings. Trade-offs exist however between costs, completeness of info and simplicity of the tool, which would need to be balanced. Increasing the scope of information and coverage 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.

In the light of higher climate ambition, the relevance of private parking facilities to enable the electrification of transport is of pivotal importance for decarbonising the transport sector and raising the share of renewable energy in the energy system. If the recharging infrastructure does not keep pace with the increase of e-vehicles, there is a great risk that there won't be sufficient recharging points in the future. In the impact assessment for the AFIR[191] it was assumed that around 60% of all recharging events will happen in private buildings, therefore within the scope of the EPBD. In light of this, only the most ambitious option E-M3 would have the potential to ensure sufficient private parking infrastructure and will be coherent with the ambition of the other F55 proposals and overall goals.

Similarly, EPCs to be effective digital tools will need to be strengthened as identified in the most ambitious option EPCI3. This is needed in order to acquire good data on building characteristics, energy use and financial implications of renovation in terms of cost savings or asset values. The current 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 and on monitoring and evaluation, both at EU and national level. Effective enforcement of minimum energy performance standards by the EU will depend on the availability of data on national building stocks, which can best be ensured by mandatory EPC databases and the transfer of those data to the Building Stock

[191]https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A52021PC0559

Observatory[192]. Enhanced building databases could also reduce the administrative burden.

The role of the SRI as enabler of a diffusion of smart technologies especially in non-residential buildings would be maximised under option 3 in line with higher ambition for zero-emission buildings and contributing to highly efficient operation modes and optimal system balance. The ongoing testing phase will provide ground for defining the next phase and mandatory introduction for certain categories of buildings.

Efficiency

Economic impacts

Comparing the four policy options, options 1 and 2 have very moderate positive impacts on value added and employment while options 3 and 4 have substantial positive impacts. Option 4 is slightly more positive than option 3.

Options 1 and 2 lead to a small increase in value added and employment compared to the baseline scenario. Option 2 performs better up to 2045 as more investment is undertaken in non-residential buildings until 2045. By 2050, renovation rates are lower and consequently, investment is lower. Combined with a reduction in value added and employment in energy supply related sectors, this counterbalances some of the positive economic growth after 2045. Economic impact remains positive, though small (about 0.13% higher than in the baseline scenario). About one third of the employment effects relate to low and medium-skilled employment in the construction, material, machinery and equipment sector as well as in the agriculture and forestry sector.

By comparison, options 3 and 4 have substantial positive impacts on value added and employment. Impacts under option 4 are more positive than under option 3. Requirements for building performance are most ambitious under the options requiring investors to implement a significant range of renovation activities in residential and non-residential buildings. Including MEPS4 in option 4 induces additional positive economic effects. Investments activities spur value added and employment, in particular in small and medium size enterprises (SME) as 95% of construction, architecture and engineering related enterprises are micro-enterprises or SMEs. Comparing the four policy options, options 1 and 2 have very moderate positive impacts on value added and employment while options 3 and 4 have substantial positive impacts. Option 4 is slightly more positive than option 3.

Options 1 and 2 lead to a small increase in value added and employment compared to the baseline scenario. Option 2 performs better up to 2045 as more investment is undertaken

[192] EU Building Stock Observatory | Energy (europa.eu)

in non-residential buildings until 2045. By 2050, renovation rates are lower and consequently, investment is lower. Combined with a reduction in value added and employment in energy supply related sectors, this counterbalances some of the positive economic growth after 2045. Economic impact remains positive, though small (about 0.13% higher than in the baseline scenario). About one third of the employment effects relate to low and medium-skilled employment in the construction, material, machinery and equipment sector as well as in the agriculture and forestry sector.

Security of energy supply is positively affected in all options, but only moderately under options 1 and 2 and having the most pronounced effect under options 3 and 4 due to significantly lower energy demand and subsequent reduced needs for energy imports from countries outside the EU-27.

Industrial competitiveness is positively affected. Most activities along the renovation value chain happen locally. For example, renovations needing architects, construction workers, machinery and equipment, project management, installers, rentals and leasing of equipment etc. Raw materials, such as insulation material, can be imported or produced domestically while heavy weight materials, such as cement, are rarely transported over longer distances. A strong EU buildings sector can lead to positive spillover effects outside the EU. Option 3 will deliver a significant contribution, the increased intensity in renovation activities will stimulate the economy, increase jobs especially in SMEs and locally.

Social impacts

As regard social impacts, the options with higher ambition have the potential to deliver significant net social benefits, if accompanied by adequate and targeted funding. Trade-offs however exist between possible regressive impacts in terms of distribution of renovation costs and their affordability, and distribution of benefits which are also expected to be the highest in low-income households. Social impacts, positive and negative, remain limited when MEPS are targeting specifically non-residential buildings, as in option 2.

In assessing the four policy options, option 1 has the lowest impact on energy poverty alleviation. Most measures included under option 1 address single family houses at a rate which is not significantly above the baseline. Option 2 has an overall medium impact on energy poverty alleviation, with more extensive requirements for Member States to implement new provisions. Option 2 has positive impacts on the share on expenditure that households need to use for energy. The effects vary greatly compared with options 3 and 4.

By comparison, options 3 and 4 have the strongest impact on energy poverty alleviation and avoiding negative distributional impacts. The measures include all residential buildings, including worst-performing building stock in multi-family houses. Option 3.b has positive impacts on the share on expenditure that households need to use for energy. For low-income households, in general the share of energy expenditure in total consumption expenditure is substantially higher than for higher income households. Therefore, renovations and subsequent energy savings in their homes, results in energy savings with positive impacts on energy poverty alleviation. A change in energy expenditure through renovation, in particular through renovating the worst performing buildings helps households with lower income. This is due to the fact that a more than average share of low income households lives in worst performing buildings. Additionally, positive effects on health benefits ('non-energy benefits') and positive impacts on social inclusion are stronger than in options 1 or 2.

Environmental impacts

The impacts on GHG emissions and energy savings are assessed under 'Effectiveness' as they are directly related to the achievement of the goals of the EPBD revision. Impacts on pollutants were considered for NO_x, SO_x and PM 2.5 – 10. Impacts are twofold: renovation activities lead to an increase in pollutants in industry while reduction in energy demand leads to a decrease in emissions, in particular in the gas and heat sector. In all four policy options, the reduction effect is higher than any increase by 2050 so that improvements in building performance has positive impacts for pollution abatement.

Effects on pollutants are very small in options 1 and 2 as the increase of renovation rates is rather low and subsequent energy reduction is moderate. Option 2 performs slightly better as more buildings are renovated at an earlier stage with positive impacts on emissions reductions through decreased energy consumption.

In option 3 and option 4 renovation rates are substantially higher leading on the one hand to higher emissions of pollutants from the building industry and industries providing materials to the building industry. At the same time, energy savings are substantially higher as well offsetting the increase in emissions from construction and renovation. Effects for all considered pollutants are most pronounced in 2050 and by then about three times better in option 3 and 4 than in option 1 and 2. SO_x emissions decline slightly more than NO_x emissions because electricity and steam and hot water production are slightly more SO_x emissions intensive.

<u>Coherence</u>

All policy options examined are in line with the EPBD framework. A number of measures aim at strengthening the existing framework and provisions – to different degrees depending on the policy option. This applies notably to requirements such as those related to Member States' long-term Renovation Strategies, the framework for EPCs regarding coverage, scope and quality as well as to the application of the smart readiness indicator. New provisions including the mandatory minimum energy performance standards or the building renovation passport largely build on and work in synergy with other elements of the EPBD such as the EPC framework. The proposed measures also complement each other in addressing different market barriers and failures, e.g. addressing the gradual phase-out of worst-performing buildings on the one hand and stimulating building renovations and new constructions compatible with the EU's medium and long-term energy and climate targets on the other.

Interplay with the 'Fit for 55' / delivering the European Green Deal proposals

To assess the coherence of the policy options in relation to the other key measures of the legislative proposals adopted in July 2021, it is useful to first provide an overview of them.

➢ **Energy Efficiency Directive**

- Set a target of 36% for final and 39% for primary energy consumption and an annual energy savings obligation of 1.5%.
- Introduce an obligation for the public sector to reduce energy consumption by 1.7% per year.
- Set an obligation for Member States to renovate 3% of public buildings to NZEB levels.
- Require systematic consideration of energy efficiency in public procurement.
- Introduce measures to help alleviate energy poverty and help vulnerable households by empowering consumers (one-stop-shops, consumer protection, awareness raising), improving affordability and access to energy and providing financial assistance and incentives for energy-efficient renovations.
- Introduce the energy efficiency first principle in policy and investment decisions.

➢ **Renewables Energy Directive**

- Set a benchmark of 49% of renewables in buildings and the obligation to increase the use of renewable energy in heating and cooling by 1.1 percentage point every year.
- Raise the use of renewable energy in district heating and cooling by 2.1 percentage points every year.
- Requests that the EPBD step-up building renovation across the EU building stock 'to make buildings fit for renewables, as most renewables can work optimally only with high energy performance buildings'.
- Require smart charging capability for non-publicly available recharging points.

➢ **Emission Trading Scheme Directive**

The proposal to extend ETS to emissions in buildings and road transport will provide an economic incentive encouraging producers and consumers of heating fuels to invest on clean energy and on the energy performance of buildings.

➢ **Effort Sharing Regulation**

The ESR proposal sets more ambitious national targets to cut emissions for sectors outside the current scope of the ETS. The revision of EPBD is also a precondition for fulfilling increased ESR national targets. Member States will need to ensure more renovations are carried out in terms of rate and depth) in order to meet the more ambitious national ESR targets.

- **Social Climate Fund**
  The SCF proposal provides for the use ETS auction revenues to provide financial support to the EU public, in particular vulnerable households, to invest in renovation or heating systems and ensure a fair transition.

- **AFIR**
- Introduce capacity-based and distance-based targets for the roll-out of publicly available recharging infrastructure for e-vehicles.
- Require Member States to develop national plans for the roll-out of recharging infrastructure, covering both publicly available and private infrastructure.

As assessed under the 'Effectiveness' criteria, the revision of the EPBD is also in line with and contributes to achieving the EU's overall climate targets of reducing the EU's greenhouse gas emission by at least 55% by 2030 compared to 1990. It also contributes to achieving climate neutrality by mid-century, as set out in the EU climate law. In this regard, the buildings sector is one of the sector where there is a high potential for cost-effective decarbonisation solutions and efforts must be ramped up.

Strengthening and aligning the EPBD with the more ambitious energy and climate targets is part of the European Commission's broader renovation wave, an action plan with specific regulatory, financing and enabling measures published on 14 October 2020. The options are also in line with the NextGenerationEU (NGEU) recovery package, as building renovation stimulates employment and growth in the construction sector, and thanks to a multiplier effect on other economic sectors provides a significant impulse for economic recovery.

As part of the European Commission's 'Delivering European Green Deal package,' the EPBD revision will work in synergy with the proposals tabled in July 2021.

In particular, the proposed policy options provide instruments to achieve the **EED** energy efficiency target:

- Direct complementarity/ interplay: requirement for Member States to renovate public buildings in the EED[193] and public procurement.

[193] Public buildings are part of non-residential buildings, and currently central government buildings are subject under the EED to the obligation to renovate yearly 3% of the floor area to meet at least the minimum energy performance requirements under the EPBD, or to apply measures achieving equivalent

- Direct complementarity/ interplay: the policy options support the achievement of the overall energy efficiency targets under Art. 3 EED and the goals under Art. 7 EED (reference is made to the current article numbers).

The EPBD supports key targets and instruments of the **RED**:

- Direct complementarity / interplay: the policy options support the increase of the renewable energy shares in the heating sector and therefore supports the targets in Article 23 of the RED II.
- Direct complementarity / interplay: the policy options contribute to providing a minimum share of renewable energy in new buildings and in major renovations (Article 15 of the RED II).

The proposed policy options complement the EU ETS (proposal to broaden the scope to cover buildings):

- The revision of EPBD and the revision of the ETS are complementary and mutually reinforcing in driving decarbonisation of the building stock. Targeted regulatory measures under revised EPBD are necessary to address market and non-market barriers to renovations that cannot be incentivised by a carbon price alone. Without such policies, a very high carbon price signal would be needed and had to be born by all consumers using fossil fuels for heating (up to 80€/tCO2 was modelled for the DEGD package and this still without significant impact on renovations but rather delivering a further fuel switch).
- In presence of a carbon price signal delivered through the ETS extension to buildings, the strengthened informative tools of the EPBD (EPCQ, DEEP, BRP), which will include also a carbon metric, will help financial investors to monetize the benefits of buildings decarbonisation and household or commercial actors to better factor in the economic benefits of building renovations and their repayment plans.
- The investments costs measures under area A will become cheaper in presence of a carbon price on heating fuels, which will therefore facilitate compliance with MEPS.

A strong link exists also with the measures under area A and the **Climate Social Fund**, which by targeting specifically the renovation of buildings of low-income households will make more affordable the investments in building renovations. This should significantly reduce their upfront costs and therefore ease MEPS compliance. It should also limit their potential regressive distributional impacts, specifically under the options in which MEPS will target also the residential sector. As illustrated in the analysis in

---

savings. This obligation has been proposed to be extended to all public buildings and renovations to reach NZEB levels in the revision of the EED.

Chapter 6, in the context of limited financial support deeper energy renovation can generate net-economic impacts for both building owners and tenants. At the same time, the improved information tools of the EPBD (EPCQ, DEEP, BRP), which will include also a carbon metric, will help the beneficiary of the CSF to plan in an optimal way their building renovations, and national authorities will be facilitated by LTRS in planning the disbursement of the CSF and of the reuse of revenues from ETS.

The proposed policy options are complementary to the AFIR:

- Direct complementarity / interplay: the policy options support the roll-out of charging infrastructure in private buildings which is directly complementary to the AFIR targets for publicly available charging infrastructure.

There is a high complementarity between ESR and EPBD revisions.

- The revision of the EPBD supports the fulfilment of increased ESR national targets, as both EU and national measures can contribute to the achievement of the national targets set in ESR.

- Member States will need to deploy more ambitious measures in the building sector to respect the increased national ESR targets, which provide a safeguard for Member States to put in place sufficiently ambitious policies.

The proposed policy options are also in line with requirements set out in the **Ecodesign and energy labelling** rules:

- Complementarity of requirements for building renovation in MEPS approaches and requirements for efficiency of heating systems under the Ecodesign Directive.
- Synergies between MEPS options that directly set the requirements on the energy efficiency of heating systems.

Subsidiarity

The subsidiarity principle requires that policy measures are decided at a level which is as close as possible to the EU public and at EU level only where necessary. In areas of shared competences, the EU therefore only acts if action at EU level is more effective than action taken at national, regional or local level.

Energy policy is a shared competence between the EU and the Member States. The legal basis for the EU to act is Article 194(2) of the TFEU, which represents the legal basis for EU policy to promote energy efficiency and energy savings. Improving the energy performance of buildings is a key vector for the European Green Deal’s objective to achieving climate neutrality, as subsequently translated into the renovation wave strategy. Improving buildings’ energy performance is also central to the EU’s green recovery.

In the assessment of the four policy options, all options have been assessed with a slightly negative score on subsidiarity, to account for the increased intensity of EU intervention in the buildings sector in relation to the baseline. Option 1 has the lowest impact on subsidiarity. Most measures comprised in option 1 leave significant room for Member States regarding implementation, e.g. by leaving provisions up to Member States for voluntary implementation or by granting significant time for implementing these. Also, many measures are developing existing provisions further or are aimed at streaming those on a voluntary basis. The introduction of minimum energy performance standards (MEPS1) to ban the sale or rental of worst-performing buildings, on the other hand, represents a new measure in the EPBD, even though several Member States already have a MEPS scheme in place.

Option 2 has an overall medium impact on subsidiarity, with more extensive requirements for Member States on large non-residential buildings. This option however also leaves flexibility for Member States regarding the specific design and scoping of relevant measures, and by limiting national MEPS to the non-residential sector, leaves margin of manoeuvre on the most relevant share of the building stock.

By comparison, options 3 and 4 have the strongest impact on subsidiarity, requiring Member States to implement a significant range of more far-reaching provisions, aimed at improving a common level of implementation and better harmonisation. Corresponding elements can for instance be found in measures MEPS1 and MEPS2, BRP3, EPCQ3, EPCSI3, ZEB3 or E-M4.

All options assessed are in line with the intervention logic, yet address the policy objectives to different extents. For assessing the subsidiarity impacts outlined above against the added value of EU action, one has to consider the fact that the existing legislative framework is not sufficient to achieve the necessary decarbonisation of the EU building stock. Stronger EU level action is therefore necessary to ensure policy alignment towards the decarbonisation of buildings, in particular through a higher renovation depth and by comprising all building segments. So far, significant room has been left to Member States in implementing the EPBD. Implementation at national level is very divergent, and sometimes not ambitious[194]. As set out in Chapter 3, with a view to the massive EU-wide challenge of building decarbonisation, a step change with stronger EU level action is now necessary to ensure policy alignment across the EU towards the required contribution of buildings to the enhanced climate and energy targets. On

[194] JRC, Progress of the Member States in implementing the Energy Performance of Building Directive, 2020.

minimum energy performance standards, their introduction would give the missing market signals for the decarbonisation of the existing building stock.[195]

The transaction-based, EU-wide renovation obligation via MEPS1 will give the necessary strong policy signal towards the phase-out of worst-performing buildings. However, MEPS1 will only cover a relatively small share of national building stocks. For the remaining building stock, MEPS 2 and 3 set target dates and benchmarks to be reached at EU level, leaving Member States room to set their national pathways and priority building types. The combination of MEPS1 and either MEPS 2 or MEPS3, possibly complemented by MEPS4, strikes the right balance between a sufficiently strong minimum framework at EU level and sufficient flexibility for Member States to adapt to national and local conditions. The EU-wide introduction of a deep renovation standard and building renovation passports are demanded by the financing industry that operates cross-border.

Stronger EU harmonisation of the new ZEB standard like in ZEB2 and ZEB3 (compared to the greater national flexibility for the current NZEB standard) is justified, especially with a view to the observed lack of ambition and too great divergence of the national implementation of the NZEB standard.[196] As regards the added value of stronger EU action on EPCs, the financing industry that operates cross-border demands a greater harmonisation of energy performance certificates as a basis for EU-wide criteria for the financing of building renovation.[197] Individuals moving within the EU and businesses operating cross-border would also benefit from more comparable energy performance certificates to enable them to make informed decisions about their housing and offices. As regards SRI, the mandatory use of SRI for specific non-residential buildings under option 3 would give an important policy signal to mobilise the industry towards the increased development of smart solutions, but for most buildings, it will be left to Member States to decide whether to require SRI use.

Considering the required step change to reduce emissions from transport to meet the enhanced climate targets, the more prescriptive elements at EU level are justified from the subsidiarity perspective. In terms of EU added value, increased charging infrastructure will accelerate roll-out of e-mobility and thereby support the development of the EU's car industry towards a future-proof business models.

Proportionality

Proportionality relates to the choice of instrument as well as to the scope and reach of requirements in light of their respective contribution and adequacy to achieve policy

[195] The joint EU ambition for all new buildings to be nearly zero-energy by 2020 has shown the significant impact of mobilising the buildings sector around a common objective, see Chapter 3 and Annex H.
[196] JRC report on NZEB implementation, see results presented in Annex H.
[197] The recently developed taxonomy for buildings already today ties certain criteria to EPC classes.

objectives. In order to be proportionate, measures should not go beyond what is necessary to achieve objectives satisfactorily, limit the scope to aspects where EU action brings added-value and limit costs for authorities and economic operators.

The policy options considered were developed in view of revising the EPBD to bring it in line with the EU's upgraded energy and climate targets. Existing legislation will not suffice to achieve the goals, therefore, a revision of the EPBD is necessary and one of the vehicles to deliver on the goals of the renovation wave strategy. Many of the assessed measures are developing existing provisions further or are streamlining these to strengthen a common level of implementation. This applies for instance to measures aimed at enhancing the coverage, quality and scope of EPCs, at advancing the application of the smart readiness indicator or at those relating to Member States' long-term renovation strategies.

A proportionality assessment is particularly relevant for most policy options having the most ambitious and therefore the most stringent measures, i.e. options 3 and 4. Overall, the measures in option 3.a with its comprehensive package of measures appears to be proportionate compared to the very significant impact and contribution it achieves. In its practical implementation and design, MEPS2 will enable the streamlining and alignment with other measures on the building stock, therefore ensuring for more proportionality with regards to national jurisdictions. Streamlining the deep renovation standard, the definition for zero-energy buildings and further requirements being part of the EU taxonomy on sustainable investments would be a further consideration in terms of limiting the complexity of rules to ensure that proportionality is correctly applied.

8. Preferred option

8.1 Introduction

This impact assessment identifies and analyses options for revising the EPBD to contribute to reducing greenhouse gas emission, putting the buildings sector at the centre of the digital and energy transitions and on the path to becoming carbon neutral by 2050. It follows the assessment conducted under the CTP which found that without the policy drivers from the EPBD, efforts from the building sector to reduce GHG will be 49% lower than what is required to achieve the Climate Law's goal of -55% GHG.

The EPBD revision is an integral part of the policy mix of measures necessary to deliver the European Green Deal. In this impact assessment, various policy options have been assessed following the guidance provided in the Renovation Wave strategy.

8.2 Conclusions of the analysis and preferred option

The analysis identified the key drivers behind the low renovation rates, the barriers to upscaling buildings and the factors limiting the autonomous development of buildings towards becoming a neutral societal asset. The analysis makes a clear distinction between factors that can be addressed through EPBD revision and aspects that are tackled by other components of the policy mix. There is a strong interplay and complementarity in that respect with the carbon price of heating fuels proposed by the Commission following the proposed extension of the current EU ETS.

Based on the knowledge of building stock characteristics in terms of age, types, tenure, technologies, energy uses and resulting greenhouse gas emissions, the analysis examined how policy mechanisms enforcing minimum levels of performance for certain buildings could prompt more building renovation. As the current EPBD does not include an appropriate instrument triggering renovations, a new one had to be identified. Guided by the feedback collected through stakeholders also in preparation of the Renovation Wave strategy, and based on EU and international experience, four different options for design were identified and their impacts assessed in packages of measures, including a measure to strengthen information tools and support renovation journeys at every stage. Besides standards to increase the performance of existing buildings, the options also consider how to make new constructions compatible with the 2050 objective and how to strengthen the modernisation of the building sector and its role in energy system integration.

Based on the quantitative and qualitative comparison of options against the two key objectives of this initiative, **option 3 'High Ambition I' emerged as the preferred option**. Policy measures under this option will lead to a substantial change and bring maximum benefits compared with current building renovations trends, while optimising the cost and administrative burden. The increase in renovation activities is considered to be in line with the stepping up of efforts needed in light of higher climate ambition, and with renovation efforts expected to be achieved thanks to the EPBD revision. This option proposes MEPSs that would entail an evolving combination of binding EU-level minimum energy standards for worst-performing buildings being rented or sold, complemented by standards set at the national level based on LTRS, gradually covering all building stock as they progress towards decarbonisation. This approach would guarantee clear market signals at EU level and comparable decarbonisation pathways, while leaving flexibility and time to adapt efforts to national conditions and to achieve the best combination of measures at national level.

The preferred option on MEPs and ZEBs will come with a comprehensive package of better information tools. The measures are summarised in the table below; more details are set out in Chapter 5, Annex E and the respective thematic annexes.

Table 8.1: Overview of measures in the preferred option

Option 3 High ambition I	Summary description of the measures of the preferred option for the revision of the EPBD

Area A. Measures to increase the number of buildings being renovated and renovation depth	
MEPS1+ MEPS2	**Minimum energy performance standards established at EU level, to be applied to worst-performing buildings rented/sold**. Buildings under transaction have to achieve at least EPC class D (or similar), and the standard will be gradually tightened. **National schemes setting minimum energy performance standards to be established by Member States**, on the basis of criteria and timeline defined in the EPBD, gradually transforming the building stock into zero-emission buildings by 2050.
BRP3 EPCQ3 DEEP2 LTRS3	Establishment of a **common EU framework for Building Renovation Passports** under the EPBD, to become mandatory for certain financial incentives. **Strengthening of Energy Performance Certificates** with the introduction of a **mandatory common EU template**, **harmonisation of highest and lowest EPC classes**, on-site visit, new quality control and reporting measures. Introduction of a **definition of "deep renovation"** in the EPBD, higher level of public funding for deep renovations. **Strengthened requirements for Long-Term Renovation Strategies (to be renamed Buildings Renovation - Plans),** to follow a shortened cycle, include additional information accompanied by new monitoring and reporting measures.
Area B. Measures to enable decarbonisation of new and existing buildings	
ZEB3	**Introduction of a zero-emission building standard for new and existing buildings**, based on benchmarks, also including a requirement to report whole-life cycle carbon emissions; **new buildings to comply with ZEB as of 2030.**
EPCSI3	**Strengthened content and greater availability of Energy Performance Certificates**: EPCs to include additional indicators (e.g. on greenhouse gas emissions, renewables), and to become mandatory for more building categories.
Area C. Measures to increase the modernisation and quality of buildings and of their systems, enabled by digitalisation of information tools	
E-M3 **(ZEB3)**	**Extension and strengthening of the requirements on recharging for electric vehicles in buildings**, establishing that all new buildings or buildings undergoing major renovations have to be prepared for EV recharging and have parking space for bikes, and that certain buildings should also be equipped with recharging points. Introduction of measures to enhance the "Right to plug".
EPCD3 SRI2	**Mandatory national EPC databases,** enhancing interoperability with other data sources and facilitating administrative compliance. **Update of the requirements related to the Smart Readiness Indicator,** enhancing linkages with other information tools and to making it mandatory for certain new buildings.

8.3 Meeting the challenges of the proposed measures

Challenges in the implementation of option 3 'High Ambition I' linked to the supply of materials, workforce and financing are set out in Sections 6.4 (see in particular Sections 6.4.1.2 'The challenges of increasing capacity in the supply markets', 6.4.2.2 'The challenges of increasing labour' and 6.4.1.1 'Investments').

8.3.1 Materials, workforce and skills

The availability of inputs for the construction sector is a precondition for the successful implementation of option 3, as the higher renovation rate and depth will entail an additional demand for materials and labour.

In the medium to long term, materials and labour supply appear to be sufficiently elastic to accommodate the additional demand for inputs in the construction sector. Historical trends laid down and compared with additional demand based on the HIGH scenario in Section 6.4.1.2 show that the market has the capacity to expand input supply in response to higher prices. As mentioned in Section 8.2 on the conclusions of the analysis and the preferred option, the Fit for 55 package overall and the EPBD specifically will bring more certainty to a sector that has in the past faced market and policy volatility. In particular, the price signal stemming from the extended ETS[198], regulatory clarity coming from energy efficiency targets under the updated EED and the progressive roll-out of MEPS as well as a higher level of information linked to updated EPCs should incentivise the construction sector to expand its capacities. Expanded capacities of both workforce and investments in fixed costs would in turn give more certainty to input suppliers to invest in expanding their own supply capacity.

However, in the short term, the implementation of option 3 could exacerbate current COVID-19 related market imbalances, as the elasticity of input supply is more limited. As a result, policy responses may be needed to ensure that supply of materials and labour grows at the requirement scale.

Regarding **materials**, increasing recyclability and material efficiency can help ease market tensions, as pointed out by several stakeholders in the consultation on the EPBD revision. Thus, more effective waste prevention and disposal policies together with the re-use of secondary materials could at the same time reduce demand for materials and ensure additional supply. Increased efforts to recycle waste and the increasing cost of landfilling for construction waste[199] already support this trend[200]. The EU will continue to support the application of circular economy principles in the construction sector in the near future. Building on the 2020 circular economy action plan, several initiatives are being developed on resource efficiency, durability and recyclability (including the sustainable products initiative, review of the Construction Products Regulation and the

---

[198] Positive anticipation of future carbon costs is among the relevant policy drivers incentivising the choice of energy-efficient or low-carbon technologies.

[199] Overall in the EU the landfill rate of construction waste fell by 11.7% between 2010 and 2018 (Eurostat 2021), and the energy recovery rate increased by 27.8% between 2010 and 2018. Eurostat 2021: Number and capacity of recovery and disposal facilities by NUTS 2 regions [env_wasfac].

[200] Overall in the EU the landfill rate of construction waste fell by 11.7% between 2010 and 2018 (Eurostat 2021), and the energy recovery rate increased by 27.8% between 2010 and 2018 (Eurostat 2021. Eurostat 2021: Number and capacity of recovery and disposal facilities by NUTS 2 regions [env_wasfac].

roadmap for the reduction of whole life carbon of buildings). Furthermore, studies are ongoing regarding possible future action on waste prevention and re-use and recycling targets for construction and demolition waste, in the context of the Waste Framework Directive.

On labour supply, the Renovation Wave communication acknowledged the 'shortage of qualified workers to carry out sustainable building renovation and construction'. As indicated in the Climate Target Plan, a key challenge is the capacity of the education and vocational training systems to train or re-train workers, as well as the ability of workers to move from one job and sector to another requiring potentially different skills[201]. For instance, it is expected that appropriate qualifications will play an increasingly important role in the construction, heating technology and refurbishment sector with new technologies and higher levels of digitalisation.

The Commission's initiatives on education, skills and training such as the pact for skills, the green strand in Erasmus+ and the Education for Climate Coalition can help to address these challenges. The accompanying action plan for the Renovation Wave strategy included a deliverable on 'Support[ing] 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'[202].

The proposal for the EED[203] recast also includes provisions for the availability of training programmes and qualification, accreditation and certification schemes as an enabler of energy efficiency improvement measures.

In addition, the updated industrial strategy of May 2021[204] announced the co-creation of transition pathways for industrial ecosystems, including construction. In a process of co-creation with Member States, industry and other stakeholders, the pathways will identify the scale of the needs, including upskilling, resource efficiency and digitalisation, and will propose action to address them.

Finally, an increase in productivity in the sector would allow for an expansion of output with less use of labour. Investments in technologies for the industrialisation of construction[205] as well as project management and collaboration tools therefore have the

---

[201] Climate Target Plan Impact Assessment, Part 1, p.86. It is important to acknowledge in this regard that transitional costs such as reskilling and upskilling have not been considered in the simulations of the Fit for 55 package's impact.
[202] The European Skills Agenda was presented in July 2020 by the Commission. Action 6 is about 'Skills to support the twin transitions'.
[203] https://eur-lex.europa.eu/resource.html?uri=cellar:a214c850-e574-11eb-a1a5-01aa75ed71a1.0001.02/DOC_1&format=PDF
[204] https://ec.europa.eu/info/sites/default/files/communication-industrial-strategy-update-2020_en.pdf
[205] For example using techniques such as prefabrication and off-site assembly, automation, modularisation and additive manufacturing.

potential to increase productivity and reduce the additional demand for labour. Industrialisation can also result in other benefits, including greater resource efficiency and less time spent on the building site (and therefore less disruption for building occupants during renovation works)[206].

While acknowledging that not all market friction stemming from higher demand and new shocks can be tempered, the combination of the proposed policies and initiatives should help to substantially address them.

8.3.2 Financing: EU, national and private financing to support the investment needs

The impact analysis identifies an additional need of EUR 152 billion annual investment in the renovation of buildings to meet the requirements and targets of the revised EPBD according to the preferred option 3 – HIGH I. This is in line with the 2030 climate target plan and the Renovation Wave communication and action plan, which identify an additional investment need of EUR 275 billion per year in building renovation to meet the RW objectives and the building renovation contribution to the 2030 emission reduction target. It will be a considerable challenge to obtain the additional EUR 152 billion on annual investments in energy renovations of buildings stemming from the preferred option for the revision of the EPBD and in particular from the introduction of MEPS.

To be able to deliver on the needs, financing should be stepped up across the board. Three main areas of actions are therefore considered key to ensure support for the revised EPBD: (1) support for building renovations for low-income households and to meet Minimum Energy Performance Standards; (2) technical assistance to develop sound building renovation projects, support programmes to develop public administration technical capacities, and programmes to train energy renovations skills; (3) cost-effective use of EU and national financing and mainstreamed information tools on the energy performance of buildings to mobilise private capital.

At EU level, compared to previous multi-annual programming periods, the current Multi-Annual Financial Framework 2021-2027, in line with the European Green Deal, has considerably increased the amount of financial support and budgetary commitment allocated to achieve EU climate and energy goals. Of the overall EUR 1 800 billion committed in the 2021-2027 MFF and the Next Generation EU (NGEU) package, 30% of it, i.e. around EUR 550 billion, has been set aside for climate-related spending. In the context of the post-COVID-19 economic recovery, significant additional financing resources have been made available to Member States through the Recovery and

[206] D'Oca et al 2018. Technical, Financial, and Social Barriers and Challenges in Deep Building Renovation. Available at https://www.mdpi.com/2075-5309/8/12/174.

Resilience Facility (RRF) under NGEU. For that purpose, the European Commission has collected on the financial market and made available to Member States a total of EUR 672.5 billion in grants and loans programmed through the national Recovery and Resilience Plans (RRPs). A mandatory climate-key in which spending for climate-related objectives[207] must represent 37% of the total expenditure under RRF and across each RRPs have been proposed by the RRF Regulation and taken up by Member States in their RRP.

The Renovation Wave strategy played a central role in the EU recovery package stimulating MS to provide for regulatory and financial support for building renovations and energy efficiency measures in their RRPs. This was also supported by the widely recognised benefits of building renovations and energy efficiency measures for economic recovery and growth, in particular for SMEs, as well as for local jobs growth potential. Therefore, as part of the RRF guidance for Member States on the preparation of the national RRPs, the Commission has published the 'Renovate' priority flagship component.

In the 22 adopted plans, so far EUR 41 billion of climate-related investments have been allocated to energy renovations in buildings, of which EUR 14.3 billion with a focus on public buildings and EUR 26.5 billion on private/residential buildings. This corresponds to 23% of all costs related to climate-related measures, or 9% of the total 22 RRPs allocation (EUR 445 billion).

Thanks also to the alignment with the EU Taxonomy, on 12 October 2021 the European Commission issued the first NGEU 15-year green bond for a total of EUR 12 billion, establishing a relevant standard on the market, achieving a strong oversubscription rate and offering excellent pricing conditions[208]. The objective will be to issue NGEU green bonds in the years to come to leverage a total amount of EUR 250 billion on the financial market. The financial resources leveraged through the NGEU green bonds will finance the programmed energy renovations in buildings to achieve a minimum threshold of 30% reduction in energy consumption, in line with the objectives and framework of the EPBD revision. The positive reply from the financial market to the European Commission's first green bond bodes well for future operations to support decarbonisation efforts in buildings after the current MFF 2021-2027. Such large oversubscription of the first NGEU green bonds, which includes the RRF planned investments in energy renovations

[207] Measures can also include measures for adapting to climate-related risks and also non-climate-related natural risks (for example earthquakes, fire and accidents). This is in line with the methodology for climate tracking set out in Annex VI of Regulation (EU) 2021/241 of the European Parliament and of the Council of 12 February 2021.
[208] Press Release: NextGenerationEU: European Commission successfully issues first green bond to finance the sustainable recovery. https://ec.europa.eu/commission/presscorner/detail/en/IP_21_5207.

with a minimum threshold of 30% energy savings, is therefore a positive sign of financial market support for EU policy and investments in this area.

Beyond the EU recovery package, financing available at EU level in the current MFF to step up energy renovation in buildings has been clearly identified as part of the SWD on 'Support from the EU budget to unlock investment into building renovation' accompanying the Renovation Wave strategy[209]. The SWD provides an overview of EU financing incentives and founding programmes to support the uptake of energy renovations in buildings towards the achievement of the Renovation Wave and climate target plan objectives. In terms of financing support for direct investments on energy renovations in buildings, beyond the RRF, the 2021-2027 MFF intervenes as well with the cohesion policy funds, the Just Transition Mechanism and REACT-EU. The cohesion policy funds remain one of the main EU instruments supporting energy renovations. In the 2014-2020 period, energy efficiency in buildings represented approximately EUR 13 billion of planned investments. It is expected that the 2021-2027 programming period will continue this support, as 30% of the European Regional Development Fund and 37% of the Cohesion Fund investments are expected to contribute to climate objectives. This will especially help Member States, regions and local authorities to boost building renovation.

Additionally, ETS auction revenues can be used by Member States to finance ambitious energy renovation in buildings. The Modernisation Fund was planned to support investments on clean energy transition in the 10 lower-income MS with 2% of the revenues from the total ETS allowances. Now, in addition, the proposed Social Climate Fund[210] will support investment to mitigate the impacts of the clean energy transition in all Member States, with 25% of the revenues from the total ETS allowances. As regards buildings, the SCF is aimed at targeting specifically energy renovations in low-income households. The SCF is considered to be a key instruments to make renovations affordable and to support the roll-out of MEPS.

To support the upscaling and mainstreaming of energy efficiency and building renovation investments and to appropriately leverage private financing, under the European Green Deal Investment Plan and the 2021-2027 MFF the Commission has also developed dedicated financing products and advisory services under InvestEU. These include the ELENA Facility and the Clean Energy Transition sub-programme of the LIFE Clean Energy Transition (CET) sub-programme. In particular, LIFE CET finances market uptake activities for larger building renovations such as the setting up of one-stop-shops; project-development assistance; a number of activities to foster behavioural changes; the

[209] SWD on 'Support from the EU budget to unlock investment into building renovation', SWD(2020) 550 final, Brussels, 14.10.2020.
[210] Social Climate Fund (europa.eu)

societal uptake of energy performance certificates; and a greater citizens-led focus on the multiple benefits of energy renovations. Research and innovation in solutions for upscaling and for deeper energy renovations will be supported through the Horizon Europe programme and in particular through the dedicated destination on energy use in buildings and the private-public partnership on 'people-centric sustainable built environment' (Built4People), a continuation of the previous energy-efficient buildings private-public partnership with a broadened scope.

National financing for energy renovations in buildings, in line with the Renovation Wave communication and following the EU's support for economic recovery through the RRF, has also been strengthened in recent years. Historically, a large majority of Member States have had in place financing schemes, direct subsidies and tax reduction to support energy efficiency measures in residential buildings[211]. Compared with financing schemes and public support for energy renovations in residential buildings, support for commercial or residential buildings owned by economic operators is less common[212]. In 2019, the JRC overview estimated a total of EUR 16 billion in national public resources spent annually across the Member States on energy efficiency renovation in buildings. Studies, including the 2019 JRC policy report, point to a necessary shift from direct grants and public direct investments to the development of more innovative financial instruments to achieve the uptake of a larger rate in terms of energy renovations. The need for a more standardised framework for energy performance certificates and deep energy renovations should be underlined here. This would make the best use of available national public resources and target public financial support in a cost-effective way where it matters most and where it is possible to reap larger benefits in terms of the energy performance increase of national building stocks. In particular, deeper energy renovations, low-income households and worst-performing buildings should have priority access to national public financing support if the 2030 energy and decarbonisation targets for buildings are to be achieved. The submission of the most recent 2020 LTRS gives a positive but rather general overview of the planned financing schemes.

The EPBD revision, and in particular the proposed new building renovation action plans to substitute the existing long-term renovation strategies, will reinforce provisions on accessible and targeted funding supported by technical assistance to fill the investment

[211] JRC, 'Accelerating energy renovation investments in buildings Financial and fiscal instruments across the EU', Economidou Marina, Todeschi Valeria, Bertoldi Paolo.
[212] Ibidem.

needs. This will increase the volume and impact of EU funding, attract private investment and mobilise further financial instruments and private financial products[213].

Building renovations are currently the subject of an unprecedented level of public financial support, which will nevertheless not be sufficient if private financing and dedicated private financial tools are not adequately mobilised. The new policy measures proposed in the EPBD revision are expected to have a strong positive effect on mobilising additional private capital, scaling up investments for energy renovations in buildings, and in general improving market conditions and investment opportunities for energy renovations in buildings.

The introduction of MEPS addresses one of the main barriers to energy-efficient renovations of buildings by intervening in building owners' demand and thus improving market conditions for energy efficiency measures in buildings. Additionally, revision of the energy performance certificates framework through increased harmonisation, reliability and comparability across the EU, as well as the introduction of building renovation passports, a definition of deep renovations, and a long-term decarbonisation trajectory toward zero-emissions buildings, will provide financial institutions, public administration, the construction industry ecosystem and building owners with more stable and harmonised information tools. It will also ensure a more certain long-term policy environment for a greater uptake of investment opportunities, development of business solutions and public strategies.

More accurate and comparable information on the energy performance of buildings and the setting up of national EPCs databases will support the de-risking of private investments in energy-efficiency renovations across the EU. This will reduce financial costs associated with energy renovations in buildings while making the targeted financial products for energy renovations (energy efficiency mortgages) more attractive for FIs to develop. It will also make it easier for building owners to access dedicated loans. Similarly, the long-term trajectory established through building renovations passports and the definition of deep renovations up to zero-emission standards allow for the long-term programming of public administration support, real-estate enterprises and building owners' business development and planning of energy renovations.

8.4 REFIT (simplification and improved efficiency)

The EPBD was revised in 2018; the main purpose of the current revision is to align the EPBD on the enhanced climate ambitions. The key objective is to increase effectiveness.

---

[213] This is in line with specific recommendations from the European Court of Auditors, Special Report 2020 'Energy efficiency in buildings: greater focus on cost-effectiveness still needed', https://www.eca.europa.eu/Lists/ECADocuments/SR20_11/SR_Energy_efficiency_in_buildings_EN.pdf.

Strengthened regulatory requirements will increase the administrative burden somewhat, notably for building owners and administrative authorities in the Member States at national and local level. However, the planned digitalisation of Energy Performance Certificates and related databases aims at reducing administrative and compliance costs.

Table 8.2: REFIT

REFIT Cost Savings – Preferred Option(s)		
Description	***Amount***	***Comments***
Digitalisation of EPCs and databases	Low	The monitoring of the building stock would be facilitated by the availability of data collected by digital tools, thereby reducing administrative costs. Digital EPCs have the potential to reduce compliance costs for building owners, if interoperability with national databases and buildings permitting procedures is ensured.

9. How will actual impacts be monitored and evaluated?

The impacts of the revised EPBD on the policy objectives set out in Chapter 4 on energy consumption, greenhouse gas emissions and renovation rates will be monitored and progress will be evaluated mainly on the basis of the provisions already in place in the current EPBD and in Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action.

Data collection and assessment will be the key monitoring tool to support Member States in keeping track of progress in the achievement of the milestones established in national long-term renovation strategies and later the national targets developed under the Building Renovation Plans, following a call from the Council.[214]

The Governance Regulation established an integrated energy and climate planning, monitoring and reporting framework. Under the Governance Regulation, Member States had to submit their integrated national energy and climate plans to the Commission by the end of 2019. The plans have to cover the five dimensions of the Energy Union for

[214] The Council Conclusions of 11 June 2021 on the Renovation Wave, call the Commission to "[…] monitor the progress made in the implementation of the renovation wave by: o analysing the domestically established progress indicators set out in Member States' long-term renovation strategies which would measure the evolution of renovation activity at European level and the energy performance of the European building stock, including deep renovations where applicable; the need to avoid a bureaucratic and further administrative burden as far as possible has to be considered; […] o developing ways to assess the economic impacts of the improvements achieved through renovation and track their effect on the real estate market; and […] o expanding the overall progress report on the renovation of the national building stock envisaged in its biennial State of the Energy Union report into a comprehensive report on all aspects of the renovation wave; […]"
https://data.consilium.europa.eu/doc/document/ST-8923-2021-INIT/en/pdf

2021-2030, including energy efficiency and buildings[215]. The link and interplay of the EPBD and the Governance Framework will be maintained with the revised EPBD provision.

To this end, Article 17 of the Governance Regulation provides that by 15 March 2023, and every two years thereafter, each Member State shall report to the Commission on the status of implementation of its national Energy and Climate Plan by means of an integrated national energy and climate progress report, which also includes specific indicators on buildings and their renovation. The biennial integrated reporting under the Governance Regulation will collect information on the progress in Member States, which will be monitored and evaluated periodically by the Commission services.

The revised EPBD will provide a clear structure for what is to be included in the Building Renovation Plans: an overview of the building sector, a roadmap with specific national targets for 2030, 2040 and 2050, implemented and planned policies and measures and the budgetary resources to implement the renovation plan. The process of monitoring the national Building Renovation Action Plans includes their assessment by the Commission services, in line with the provisions of the Governance Regulations.

Reporting on progress for key indicators and other important elements under the EPBD, together with an analysis and breakdown of the factors influencing it, also takes place periodically through the 'State of the Energy Union Report' required by Article 35 of Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action[216].

Key indicators and data to be used for reporting purposes will also rely on statistics already available from Eurostat energy balances. Data collection for energy consumption in households by end-use type allows monitoring of the specific use of renewable energy in households' heating and cooling. Additionally, Eurostat structural business statistics allow monitoring of the overall evolution of workforce, turnover and value-added in the construction sector. The impact on household energy expenditure and effects on energy-poor households will be monitored through the Eurostat household budget survey (HBS) and the survey on income and living conditions (SILC), following the indicators set out

[215] In particular, the national Energy and Climate Plans should include information on the national long-term renovation strategy, the cost-optimal minimum energy performance requirements, the number of nearly zero-energy buildings and the equivalent to inspections of heating and air-conditioning systems reports.

[216] The Commission has to submit a State of the Energy Union report by 31 October of every year to the European Parliament and the Council, and the report must include, biennially, an overall progress report on the renovation of the national stock of residential and non-residential buildings, both public and private, in line with the roadmaps set out in the long-term renovation strategies that each Member State has to establish in accordance with Article 2a of the EPBD. Every four years, an overall progress report must be submitted on Member States' increase in the number of nearly zero-energy buildings.

in Commission Recommendation (EU) 2020/1563 and associated SWD (2020) 960 final. There is continuous cooperation between DG Energy and Eurostat to improve the statistical basis for monitoring energy efficiency in buildings. As a result, an hoc data collection exercise under SILC contained a module for collecting data about households' heating systems and fuels used, recent renovation (thermal insulation, windows, heating systems) and building component affected, type of windows (optional) and year of construction (optional). There are also discussions with the Eurostat population and housing statistics team to further improve building-related data availability on similar lines as for SILC.

A big step towards transparency and monitoring of national methodologies to calculate the energy performance of buildings is represented by updates to the provisions in Annex I, requiring Member States to describe their national calculation methodology following the key European overarching standards on the energy performance of buildings, namely EN ISO 52000-1, EN ISO 52003-1, EN ISO 52010-1, EN ISO 52016-1, and EN ISO 52018-1, or superceding documents. Member States must also report the choices made and the data sources for the definition of primary energy factors or weighting factors according to EN 17423 or superceding document.

The monitoring and evaluation would be facilitated by the increasing availability of data collected by digital tools. The EU Building Stock Observatory collects, and makes public and accessible, data on the transformation of the building stock which would allow for systematic monitoring of key parameters, including renovation rates of the EU building stock. The digitalisation of energy performance certificates and their national databases could gradually feed into it, allowing for systematic tracking of the EU building stock's performance.

The JRC will continue developing specific analyses and studies focusing on the implementation of EPBD measures that contribute to its overall policy objectives.

An additional data source for monitoring the impact of end-use energy efficiency policies in buildings are the databases of Odyssee-MURE[217], an EU project running for almost two decades which collects relevant energy consumption and energy efficiency data through a network of energy agencies from all the EU countries.

The transposition and implementation of the Directive will be followed up by the Commission after the transposition deadline. In addition, the Commission will work with the Member States through the Committee of Article 26 and other well-established

[217] Odyssee-MURE website at: https://www.odyssee-mure.eu/.

networks such as the Concerted Action on the EPBD[218], which provides a structured dialogue on transposition as well as a forum for the exchange of best practices.

[218] Concerted Action on the EPBD website at: https://epbd-ca.eu/.

EUROPEAN
COMMISSION

Brussels, 15.12.2021
SWD(2021) 453 final

PART 2/4

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}

Table of contents

Annex A: Procedural information

Lead DG, Decide Planning/CWP references

DG ENER, PLAN/2020/8667, Commission work programme 2021 (COM(2020) 690 final) Annex I. 1.k.

Organisation and timing

The revision of the EPBD was announced in the Renovation Wave Communication of 14 October 2020.

The following DGs were part of the Inter-Service Group: SG, AGRI, BUDG, CLIMA, CNECT, COMM, COMP, DEFIS, EAC, ECFIN, ECHO, EMPL, ENV, ESTAT, FISMA, GROW, JRC, JUST, IDEA, MOVE, REFORM, REGIO, RTD, SANTE, SJ, TAXUD. Three meetings took place on 30 April 2021, 11 June 2021, 1 July 2021, 15 October 2021, 8 November 2021 and 26 November 2021.

Consultation of the RSB

A meeting with the RSB took place on 15 September 2021. On 18 September 2021, the RSB issued a negative opinion. An improved Impact Assessment was submitted on 20 October, addressing the recommendations provided by the Board in its first opinion. The following table shows the RSB recommendations and the changes made to respond to them.

Opinion - What to improve	How it is addressed
1.1 - The problem definition should clarify why the initiative is needed with an increasingly and progressively decarbonised energy sector, and why the Fit for 55 package is not sufficient to address the objectives. 1.2 - The problem definition should develop the noneconomic barriers in sufficient detail in the problem drivers. 1.3 - It should demonstrate with evidence the uniformity of the problems and problem drivers across Member States. 1.4 - The scope of the problem definition should be limited to what this initiative addresses and should exclude other building deficiencies.	1.1 – The problem definition has been clarified accordingly in the revised version. In Chapter 1 the role of the EPBD revision as integral part of the package of measures composing the "Fit for 55" has been made clearer. The specific policy drivers attributed to the EPBD revision by the CTP and necessary to achieve a decarbonisation of the building sectors are elaborated upon. To disentangle the role of EPBD revision in "Fit for 55" package, a new counterfactual scenario "without EPBD" has been run. The results of the counterfactual scenario are presented in Chapter 6.2 and clearly show that the policy proposals from the "Delivering the Green Deal" package of July will not be sufficient to achieve the EU climate and energy goals without a strengthened EPBD. In Chapter 1 and in Section 2.5 explanations are given on the reasons why it is needed to combine renewable deployment and energy efficiency improvements and on the need to enhance buildings' performance in a decarbonised energy sector. 1.2 – The problem definition has been revised to address this point, including notably (but not only) in the problem drivers. Non-economic barriers to buildings renovations are further developed and detailed in a new section in Chapter 2 (and in

	Annex E). 1.3 – The uniformity of the problems and problem drivers is further substantiated to address this point. Additional evidence on problem distribution across the Member States is included in a new section on the building stock in Chapter 2, based on data from Eurostat, Long Term Renovation Strategies (LRTS) and other sources, underpinning the presence of common barriers to buildings renovations. 1.4 – The demarcation of the scope of the problem definition has been revised accordingly, making it clearer and leaving out those elements that this initiative cannot address. In Chapter 2 a distinction is made between the barriers and drivers that can be addressed by the EPBD revision and those that are outside its scope.
2.1 - The report should justify why it does not include the already proposed Fit for 55 measures in the baseline. 2.2 It should explain why there is no common approach on the baseline between follow-up initiatives to the July Fit for 55 package. 2.2 - If the report uses the same baseline as this package, the impact analysis should distinguish between the effects of the EPBD and of the package.	2.1 – The report has been revised to adequately justify why it does not include the July components of the Fit for 55 package in the baseline. Section 5.1 demonstrates that given that the EPBD revision is an integral part of the “Fit for 55” efforts and from this perspective not a ‘follow-up initiative’ to the July package (but simply coming slightly later), it is appropriate to use the same baseline approach followed in the Impact Assessment underpinning the proposals adopted in July 2021. The report explains why there is no common approach on the baseline between the July part of the package, and the initiatives that will be adopted in December. More specifically, it is additionally explained that initiatives not contributing per se to decarbonisation (which is the case for the revision of the Energy Performance of Buildings Directive) and mainly addressing energy infrastructures (as other parts of the December proposals) have followed a different approach. 2.2 – Since the report uses the same baseline as the proposals in the July package, the impact analysis further distinguishes between the effects of the EPBD and of the already adopted proposals. From the “Fit for 55” core scenario MIX, a new dedicated counterfactual scenario “without EPBD” has been run to disentangle the EPBD effects. The results of the counterfactual scenario “without EPBD” are presented in Chapter 6.2 and 7, showing the expected impact of the revised EPBD. In Chapter 6 the assessment of impacts focuses only on the options for the EPBD revision, and the interplay with other measures are clearly outlined.
3.1- The report should clarify the link between the reformulated problem drivers and the objectives and options. 3.2 - It should clarify which emission coverage (e.g. direct, operational, indirect/embedded, full life cycle) corresponds to each of these dimensions and why. 3.3 - It should reflect whether this may lead to regulatory overlap (e.g. with construction material standards).	3.1 – The reports has been revised to clarify these links. The explanations and illustrations on how the policy options address the problem drivers and contribute to the objectives have been updated and clarified. 3.2 – The specific emission coverage of each dimension is now made explicit and argued for A section in Chapter 1 clarifies upfront that the scope of GHG emissions covered in the Impact Assessment, is in line with the scope of the EPBD provisions, which always address operational emissions unless otherwise specified. The specific dedicated measures

	proposed addressing lifecycle emissions are clearly presented. This is reflected also in the section on environmental impacts in Chapter 6. 3.3 – The slight extension of the emissions coverage complements and does not overlap with other initiatives and this is further reflected in the revised text. In Chapters 1 and 5 and Annex K the additional elements provided on the interplay with other initiatives addressing life-cycle emissions clarifies that there is no overlap with them. This is further assessed and confirmed in particular as regards the Construction Product Regulation currently under revision.
4.1 - The options should identify and highlight the main policy choices and relate them to the reformulated problem drivers and identified gaps to be filled. 4.2 - The current approach does not demonstrate that all measures are necessary, in particular the obligation to renovate buildings. 4.3 - The report should make a clearer distinction between 'main measures' and 'supporting measures', and apply it more coherently. It should specify the precise content and parameters of all measures.	4.1 – The options identify clearly the main policy choices and link them back to the problem drivers and gaps that the revision aims to tackle. Across Chapter 5, the measures proposed are better put in relation to the problems identified and their drivers. 4.2 – The text further substantiate how measures in the current approach are necessary, notably as regards minimum energy performance standards and building renovation, which is a key gap that the revision aims to fill in. The findings from the Climate Target Plan demonstrating the need for higher building renovations to achieve decarbonisation in the building sector are presented in Chapters 1 and 6. The results from the counterfactual "without EPBD scenario" in Chapter 6 confirm those findings. In Chapter 5, the need for minimum energy performance standards in the EPBD to address the current lack of specific measures to increase energy renovation (rates and depths), by reducing the non-economic barriers preventing renovations from happening, is clearly presented and explained. 4.3 – To address this comment, the distinction between main and supporting measures is not made anymore in Chapter 5 and all measures are explained in detail.
5.1 - The report should demonstrate better the respect of the subsidiarity principle of this initiative. 5.2 - It should be more explicit on the inter-play between the harmonised objectives at EU level and the flexibility for Member States (e.g. the use of fiscal measures). 5.3 - To demonstrate the need for EU intervention, it should explain clearly what would be the cross-border effects of a lack of building renovation in some Member States.	5.1 – The respect of the subsidiarity principle has been further demonstrated. Sections 3.2 on the necessity of EU Intervention and 3.3 on added-value better relate to the problems – common to all Member States - addressed by the initiative. The assessment of subsidiarity of the options in Chapter 7 has been clarified. 5.2 – The interplay between EU level harmonised objectives and national flexibility has been expanded. The description of the policy options and measures in sections 5.2 and 5.3 makes it more explicit which requirements would be harmonised (e.g. on new buildings) and where Member States would keep flexibility (e.g. on priority segment of the building stock to address with national minimum energy performance standards). 5.3 – To demonstrate the need for EU intervention, section 3.2 better describes the need to pick all low-hanging fruits of renovation of the worst performing buildings to meet the targets. In section 3.3 explanations are added on cross-border

	value chain of buildings renovation, and on the fact that without standardised/aligned renovation measures and policy tools, there will not be sufficient uptake of the necessary private financing, and barriers to investment opportunities and to a stronger market for energy renovation will persist.
6.1 - The report should assess the feasibility of the options, given the possible shortage of (skilled) labour and materials. 6.2 - It should analyse the required capacity changes and assess their feasibility and impacts in a realistic macroeconomic scenario. 6.3 - It should also be clear about the emissions resulting from renovations themselves as compared to those from an un-renovated building using decarbonised energy.	6.1 and 6.2 - In Chapter 6 new sections on “The challenges of increasing capacity in the supply markets” and section on “The challenges of increasing labour” assess the increased materials and labour needs and relate them to historical trends. A new sensitivity analysis of the impact of the EPBD revision on jobs and skills examines the expected implications also in relation to the Fit for 55 Package overall (the upper bound for the additional needs). In Chapter 8 the Commission policies addressing upskilling needs and materials needs within the construction ecosystems are presented. 6.3 - Evidence on emissions from renovations themselves are presented in Chapter 6 (as compared to those from an un-renovated building using decarbonised energy) together with their mitigation measures.
7.1 - The report should disaggregate the positive and negative impacts across different stakeholders, e.g. income groups, renters/owners, sectors and Member States. 7.2 - It should not simply assume that sufficient financing or mitigating measures would be available when assessing distributional effects. 7.3 - It should take into account the heterogeneous characteristics of individual Member States including in terms of building type and age, property ownership and differing liabilities of owners, leaseholders and tenants; and how these differences may lead to uneven impacts. 7.4 - The report should discuss the total investment needs and identify possible funding mechanisms that may remove some of the barriers.	7.1, 7.2 and 7.3 - In Chapter 6 some of the economic impacts have been further disaggregated by climatic zones. To better understand how national differences could affect the economic impacts, a sensitivity analysis to simulate the different economic impacts of renovation requirements for different types of buildings and renovation types has been applied. It shows how the economic impacts could vary for building (unit) owners or tenants, also in presence of financial support of different intensity. 7.2 and 7.4 - On top of the existing section on investments (in Chapter 6), in Chapter 8, a new section links the investment needs with the Union, national and private financing available. The uncertainties post-2027, the areas towards which funding mechanisms should focus on and references to how the preferred options will help stepping-up financing have been provided as well.
8.1 - The report should better reflect the stakeholder views throughout the report, including in the problem definition, option construction and the choice of preferred option. 8.2 - It should explain how it took into account minority views.	8.1. and 8.2 - The views expressed by stakeholders, particularly on the policy measures identified have been further integrated into the problem definition, policy options and assessment of options and throughout the Impact assessment overall. Concerns voiced and minority views in particular, especially on affordability and renovation hassle, have been better reflected as well.
9.1 - The report should identify the indicators and data sources needed for an adequate monitoring framework. 9.2 - It should define from the outset what success would look like, and when would be the most appropriate moment for an evaluation.	9.1 and 9.2 - In Chapter 9 the EPBD data to be collected through the revised EPBD monitoring framework is presented and the key indicators to assess progress towards the key objectives and the respective data sources are identified. It is also explained that the assessment of LTRS (to become Building Renovation Action Plan) would allow to evaluate progress, in synergy with the Governance Framework mechanisms.

The Regulatory Scrutiny Board issued a second negative opinion on 18 November 2021. Following the opinion, the legislative proposal for the revision of the EPBD has been adapted to address the concerns raised. The modifications made to the legislative proposal are described in the "Explanatory memorandum" accompanying the legislative proposal.

The table below includes the recommendations from the RSB and how they have been addressed.

Opinion - What to improve	How it is addressed
(1) The problem definition should clarify why the other measures in the Fit for 55 package are not sufficient to address the greenhouse gas reduction objectives in the buildings sector. It should specify the remaining gap that would be left for the EPBD to fill after the combined effect of the inclusion of the building sector in the Emissions Trading System and, in particular, the more ambitious targets for Member States in the Effort Sharing Regulation, which also includes the buildings sector.	The chosen set of options reflected in the legislative proposal has been reviewed and further calibrated following the second opinion from the Board. As a result, the legislative proposal has been revised and the scope of the proposed provisions on existing buildings reduced. More specifically, regulatory measures focus on those segments of the buildings stock in which the non-economic barriers to energy renovations are more acute and more difficult to be addressed by economic measures or targets, and where the broader macro-economic and social positive impacts can be maximised. The interplay between the EPBD and the ESR has been further explained in [Chapter 7, Annex K] and in the Explanatory memorandum to the legislative proposal. In short, the measures in the EPBD would support the achievement and not substitute the targets set under the Effort Sharing Regulation (ESR) and it supports their achievement.
(2) The report should better justify why the drivers that are assumed to capture the impacts of the EPBD to construct the new MIXwoEPBD modelling scenario can be fully attributed to the EPBD. In particular, it should explain why increased renovations and higher use of renewable heating and cooling equipment would not also or primarily result from Member States' actions under the Effort Sharing Regulation.	It is important to clarify that the MIXwoEPBD counterfactual scenario does not capture all drivers to building renovation as if they all were to be attributed to the EPBD. Instead, this counterfactual scenario does not exclude all drivers to energy renovations, but only those that can be largely attributed, with certainty, to a strengthened regulatory framework in the EPBD revision. Energy renovations still occur in the MIXwoEPBD scenario at a higher rate in comparison to the baseline, thanks to the incentives and stimuli from the measures in the July Fit for 55 package, but at a much lower scale, especially for what concerns deep renovations. Based on MIXwoEPBD scenario, in absence of EU measures to increase the rate and depth of energy renovations, national measures would have to fill the gap to ensure the achievement of the national targets established through the ESR and the -55% GHG emissions reduction goal by 2030. In other words, the proposed revision aims at fostering both push and pull factors supporting buildings' decarbonisation in conjunction with the incentives for national action established in the proposed ESR (and the carbon pricing impacts of the new emissions trading system for fuels used in buildings).
(3) The report should better analyse and demonstrate the respect of the subsidiarity principle of this initiative. It should justify why it includes split incentives in the problem drivers, even though the analysis shows that these are best tackled at Member State level due	The retained option in the legislative proposal has been revisited and amended as a follow up to the opinions of the Regulatory Scrutiny Board. Careful attention has been put on respecting subsidiarity and proportionality and taking into account the particularities of building stocks across different Member States, whilst maximising the magnitude of the

to their heterogeneity. More generally, the report should systematically integrate into its analysis that barriers to renovation are country-specific (as is demonstrated by the added information on the European building stock) and that there are only limited (potential) cross-border effects in the fragmented buildings sector.	achieved energy savings, cost-effectiveness and energy poverty alleviation impacts. While acknowledging the heterogeneity of the EU building stock, the evidence provided in Chapter 2 demonstrates that the barriers to energy renovations are largely common and similar across EU countries, which justifies the role of EU intervention. However, given the need to ground the subsidiarity and proportionality of the proposal on a more solid evidence base, the EPBD revision draft proposal has been reviewed following the opinions from the Regulatory Scrutiny Board and aligned with Option 2 on medium ambition for several aspects, and medium to low ambition as regards measures tackling the renovation of existing buildings, whilst keeping Option 3 - high ambition I approach for new buildings and their modernisation. More detailed description of the choices made to design the legislative proposal in comparison to the preferred option in the Impact assessment is provided in the Explanatory Memorandum of the legislative proposal. In addition, as regards cross-border effects, the explanatory memorandum highlights that even if buildings do not move across borders, building-related financing as well as the technologies and solutions that are installed therein do, from insulation, to heat pumps, efficient glazing, or photovoltaic panels. EU action leads to a modernisation of national regulations in the building sector to meet the decarbonisation objectives, opening wider markets for innovative products, many EU-manufactured, and enabling cost reductions when they are most needed, and industrial growth. Even is possibly more limited than those in other more ‘movable’ sectors, these cross-border effects are not to be neglected.
(4) The options should be organised in a way that highlights political trade-offs and relevant political choices. The construction of options should allow for assessment of which measures are decisive for reaching the objectives and which ones should not be selected because of proportionality concerns.	As a follow up to the opinions of the Regulatory Scrutiny Board, the measures selected for inclusion in the proposed legislative text has been significantly reviewed and revised. In addition, a description of the choices made to design the legislative proposal in comparison to the preferred option in the Impact assessment, and to ensure that the proposal is proportionate to the goals of the initiative, is provided in the accompanying Explanatory Memorandum.
(5) The comparison of options should be more coherent with the analysis. It should specify the differences across the options for proportionality and subsidiarity and integrate these in the respective scores. The report should justify why it considers that the options perform similar to the baseline on subsidiarity, even though they significantly reduce the room for manoeuvre of Member States to deal with county-specific barriers to renovation. It should more convincingly argue, based on available evidence, why the preferred option performs better than other options.	To address this point, the assessment and scoring of subsidiarity in Chapter 7 has been amended to clarify the difference with the baseline, highlighting for each options the room for manoeuvre of Member States to deal with country specific barriers to renovation.
(6) The report should further clarify how the initiative will be monitored and evaluated. It	Monitoring and reporting of this initiative will be grounded on the common tools established under the Governance

should, in particular, specify what information Member States will have to provide in the annexes to their building renovation action plans and how the Commission will use this information. It should also stipulate how and when the Commission will evaluate the overall performance of the EPBD.	Regulation framework, which ensures that a transparent and reliable planning, reporting and monitoring system is in place. Accordingly, the description of chapter 9 on monitoring and evaluation has been further clarified, highlighting that this point and coherence with the already existing framework for National Energy and Climate Plans under the Governance Regulation. The adjusted legislative proposal specifies which information of the national Building Renovation Plans are mandatory and which ones are voluntary and it amends the existing review clause. The date for the next review pursuant to Article 19 is set to 2028. The review clause makes explicit reference to the possibility for the Commission to assess and possibly introduce further binding minimum energy performance standards if the implementation of minimum energy performance standards by Member States does not sufficiently deliver.
(7) The report should find a better balance between its core messages in the main report and the detailed discussion and analysis that should be part of the annexes.	In order to better balance core messages in the main report and the detailed discussions and analysis in the annexes, Chapter 2 has been revised and the additional subsection including details on the building stock (The European building stock and buildings ownership structure) has been moved to the annexes.

EVIDENCE, SOURCES AND QUALITY

The preparation of the Impact Assessment has benefitted from several sources of evidence and analysis. As regards the current EPBD framework, the outcomes of the evaluation carried out in 2016 provided a relevant basis which has been reflected in the development of the policy options, with a view to overcome the weaknesses of the existing provisions in light of higher climate ambition. Given that the evaluation exercise was completed recently, and that the EPBD was reviewed in 2018 and the new measures introduced had to be transposed only recently (2020), it was considered of limited added value to perform another evaluation back-to-back to the ongoing revision. The analysis and assessment of compliance and of the practices in the Member States was based on the analysis performed by JRC for DG ENER, which regularly prepares reports on a number of topics linked to the implementation of the EPBD, namely NZEBs, EPCs, cost-optimal methodology, financial instruments to support buildings renovations, split-incentives, LTRS, and overall compliance to the EPBD. The EPBD Concerted Action initiative produced several thematic reports based on the analysis of the national experiences of implementation of the EPBD and best practices going beyond the legal requirements, which provided relevant input and were quoted throughout the Impact Assessment. Dedicated sessions on topics relevant to the EPBD revision took place also at the (virtual) EPBD Concerted Action[1] plenary meetings of November 2020 and May 2021.

[1] https://epbd-ca.eu/

The quantitative and qualitative assessment of impacts and administrative costs and the analysis of the input from stakeholders was supported by a specific technical support contract[2]. This study is quoted in the document as 'Guidehouse et al.' .The analysis within this contract included a substantial literature review on topics of interests, with a view of informing the assessment with the latest academic and research findings on the topics relevant to the analysis. The modelling of the baseline and of impacts built substantially from the datasets, technical and economic assumptions, and the overall assessment made in the CTP and the initiatives under the 'Fit for 55' package through the Primes model. As regards the data related to the technical characteristics and trends of the building stock, the main statistics and data used, also to populate the dataset underlying the models used, refer to the Building Stock Observatory, EUROSTAT indicators and Odyssee-Mure datasets[3]. For social impacts EUROSTAT data were used as well as evidence from the Energy Poverty Advisory Hub[4]. Several studies and analysis from stakeholders, think-tanks, research organisations, the International Energy Agency, the Intergovernmental Panel of Climate Change were analysed in preparation of this Impact assessment. These are either cited directly as sources throughout the document or in the underlying studies.

Several ongoing or recently concluded studies conducted for DG ENER contributed to the development of the policy options, in particular a study on Lessons learnt, feasibility of BRP, big data for buildings, renewable technologies, heating and cooling appliances, competitiveness of construction, Smart Readiness Indicator, renovation rates and on whole-life cycle carbon. These studies were cited in the relevant parts of the Impact Assessment. Results from several ongoing research and innovation projects funded under the Horizon2020 programme were also assessed and provided valuable input to the analysis, in particular as regards buildings stock data, buildings technologies, skills and Energy Performance Certificates.

[2] Technical assistance for policy development and implementation on buildings policy and renovation Support for the ex-ante impact assessment and revision of Directive 2010/31/EU on energy performance of buildings Service request 2020/28 – ENER/CV/FV2020-608/07; DG Climate Action CLIMA.A4/FRA/2019/0011. The study under this contract is performed by Guidehouse, Trinomics, Öko-Institut and Ricardo-AEA.
[3] Energy Efficiency Trends & Policies | ODYSSEE-MURE
[4] EU Energy Poverty Observatory | EU Energy Poverty Observatory

Annex B: Stakeholder consultation

1. Synthesis of consultation activities

This Annex provides a synopsis of the stakeholder consultation strategy carried out to gather stakeholder views and insights to feed into the revision of the EPBD.

The consultation strategy aimed at ensuring, via a series of consultation activities, that relevant stakeholders had the opportunity to express their views and feed into the Commission's work on all the elements relevant to the revision of the EPBD. It has integrated and built upon the results from the very extensive and in-depth public consultation for the Renovation Wave that took place between January and September 2020[5].

A variety of methods and tools has been used to ensure a comprehensive and well-balanced consultation process:

- An **Inception Impact Assessments** published on the Have Your Say portal on 22 February 2021 was open for feedback during 4 weeks.
- A 12 weeks **public consultation**, based on a structured online questionnaire in the EU Survey tool, was published on the Commission Have Your Say portal from 30 March 2021 to 22 June. The public consultation covered the scope, type and design of possible policy options.
- **Five dedicated and targeted workshops** were organised with various stakeholders between 31 March and 3 June 2021. These events were organised thematically to address specific areas for policy options.
- Additional engagement with stakeholders has taken place on an ad hoc basis, to the extent that this was deemed necessary in addition to the previous activities.

The consultation on the Inception Impact Assessment and the Public Consultation questionnaire were open to the public while the workshops were targeted to certain stakeholders.

At meetings of the EPB Committee and the Energy Working Party and sessions of the Concerted Action plenary meetings, to the Commission informed national delegations and administrations and collected their views.

2. Outcome of the consultation activities

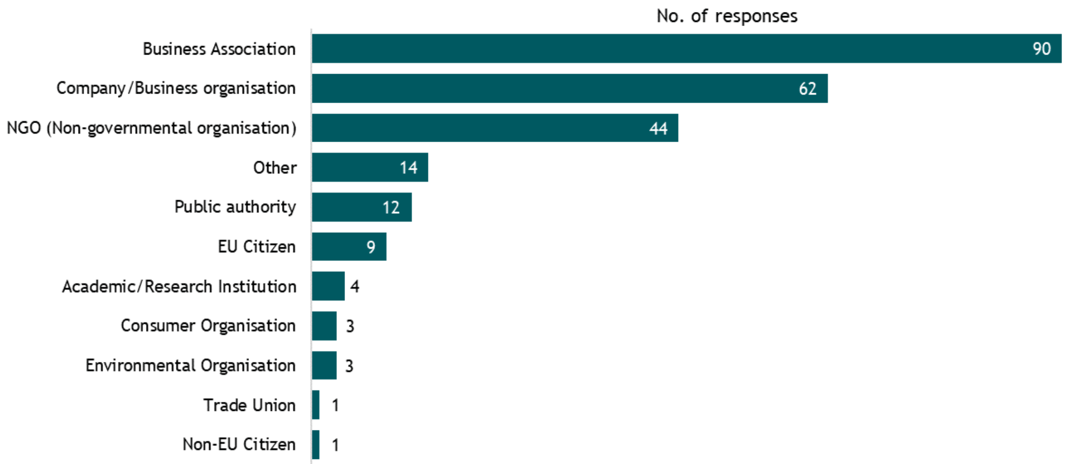
[5] https://ec.europa.eu/energy/sites/default/files/stakeholder_consultation_on_the_renovation_wave_initiative.pdf

2.1 **Outcome of the Consultation on the Inception Impact Assessment** (22 February 2021-22 March 2021)

The consultation encouraged inputs in free format and uploading position papers, in reply to the Inception Impact Assessment. 243 feedback submissions were received, of which 154 included an attached position paper.

The feedback came mostly from business associations, companies /business organisations and NGOs (figure B1). 22 SMEs responded to the survey directly, and several more were represented by the associations participating into the consultation. The objective of this consultation activity was to engage with stakeholders in a structured manner and allow for an elaborate input on the issues that the revision of EPBD would tackle, especially regarding the introduction of mandatory minimum energy performance standards, the update of the framework for EPC and the introduction of Building Renovation Passports and a Deep Renovation standard. The results of the feedback were analysed using Atlas.ti (text processing software).

Figure B.1: Stakeholder type- Inception Impact Assessment feedback responses



The feedback covered a range of topics, including EPBD general aspects and principles, specific measures/indicators, social/economic impact, climate/environmental impact and building technologies. The main points raised by stakeholders are summarised per topic in the following sections.

2.1.1 General aspects

- **EPBD Revision**

Overall, there is wide support for the EPBD to be amended and translate the actions proposed in the Renovation Wave and the increased ambition towards building decarbonisation into legislation. There was also support for regulatory measures to be combined with voluntary ones. No participants were in favour of an unchanged framework.

Amongst the non-legislative measures, the diffusion at scale of one-stop shops supporting energy efficiency in building renovation projects received vast support. Additionally, awareness of the benefits and savings of energy efficiency measures was considered as needing to be increased for European citizens, public authorities and SMEs. Stakeholders also supported the exploration of a lifecycle carbon approach. Energy communities were also acknowledged as an important element for reaching energy efficiency goals within the buildings sector.

While the importance of carbon metrics was highlighted, the majority of respondents considered that they should not be prioritised to energy performance as currently defined in the EPBD. It was considered that the EPBD review should reflect the Energy Efficiency First principle.

- **Renovation rate**

Several stakeholders indicated that renovation rates need to drastically increase to reach 2030 and 2050 climate targets. Stakeholders suggest the following mechanisms: Minimum Energy Performance Standards; regulatory measures that reduce costs and rapidly increase scale of renewable energy; Building Renovation Passports; more and highly-qualified workforce; strengthened rules for Energy Performance Certificates at EU level, and in general, more ambitious and binding energy performance requirements. Stakeholders warned that increasing the number of renovations should not lead to a decrease in their quality.

- **Financing**

Stakeholders indicated that renovation obligations must go hand in hand with financing. Targeted support for vulnerable households is essential. Innovative ways to release more funding for energy efficiency improvements from public and private sources should be explored. Technical knowledge by financial institutions to reduce the risks of investments in buildings and reliable data (e.g. from EPCs) are needed. The importance of sharing best practices in shaping national support schemes, and of Energy service providers specialised in delivering and financing energy efficiency projects was also indicated. New construction and charging infrastructure were also mentioned in the context of financing.

2.1.2 Economic and social aspects of buildings renovations

- **Energy Poverty**

Tackling energy poverty should be a priority. As already highlighted above, stakeholders suggested helping specifically vulnerable households, addressing poorly insulated buildings and accompanying minimum energy performance standards with financing tools and technical assistance. Other specific measures suggested are the following: loans for renovation that do not have to be repaid until the property is vacated, assistance to local authorities for planning and financing renovations for energy poorest. Highlighting the benefits (health/comfort/safety) of deep renovations can encourage low-income and low-energy tenants to engage in renovation.

- **Rental housing**

The EPBD revision should not negatively affect the affordability of housing for tenants. Public and private financing schemes should be used to help tenants pay for major renovations. The EPBD should address the problem of split incentives between tenants and landlords. Energy Performance Certificates are seen as an important tool for landlords to provide transparency on the energy needs of a building.

- **Health**

The EPBD should make air quality objectives explicit and set requirements for indoor environment quality and health in various provisions, such as LTRS, NZEB, MEPS, EPCs and BRP. Article 10 could be amended to link financial measures with improvement of the indoor environmental quality.

- **Skills**

Upgrading and re-skilling should include workers of all ages and from different sectors in order to increase the available workforce in the construction sector. The EPBD must ensure that adequate efforts are made at national level to address shortages of skilled workers. The revision of the EPBD should also explore synergies with other EU initiatives on skills.

2.1.3 EPBD measures

- **Minimum Energy Performance Standards (MEPS)**

The phased introduction of MEPS for all building types is key. MEPS should be designed at national level, with sufficient lead-time, respecting the requirements of economic rationality, adapted to different types of buildings (occupied/rented/commercial) and accompanied by a financial framework.

MEPS should be introduced gradually, based on EPCs and real national data on the building stock. Technical and organisational assistance is needed for owners and tenants, as well as for training of the workforce. MEPS should start with the renovation of the worst performing buildings for sale or rent, both for residential and non-residential buildings. MEPs should be final-energy based to ensure a greater focus on effective decarbonisation of buildings. Some stakeholders indicated that MEPS should be developed in conjunction with existing national or European frameworks, such as Ecodesign and Energy Labelling.

- **Building Renovation Passport (BRP)**

There is general support for the EPBD to introduce a BRP which provides adequate estimation of the renovation potential of buildings and helps create a long-term renovation roadmap. BRPs should be: linked with EPCs; digital; include a carbon component; take air quality into account; cover the carbon performance of the energy system; be integrated with MEPS; and include information on accessibility of the building. BRPs could be mandatory for all Member States and for all buildings at a specific time in the life of each building. Also, BRPs should be supported with public funding.

- **Energy Performance Certificates (EPCs)**

For several stakeholders, the reform of the EPC framework is a priority. There is a need to improve their quality, so that they can be widely used to determine the performance of buildings and the compliance with MEPS. The EPBD should address the current overlap between EPCs and energy audits (under the EED). EPCs should be carried out by certified professionals, using the common EPBD framework, and with a shorter period of validity. EPCs should provide relevant data to end-users, based on energy bills.

In terms of metrics, EPCs should include additional information, such as CO_2 emissions, indicators reflecting climate resilience, indoor environmental quality, difference between calculated and measured energy, thermal and seasonal comfort, financial valuation, circularity, sustainable mobility, smart readiness indicator. Stakeholders also suggest that energy management options should be better reflected in EPCs. Accelerating the digitalisation of EPCs would make them more reliable and ensure that energy and CO_2 savings are real. National EPC databases should be more accessible, transparent, and closely integrated with digital building logbooks.

Some stakeholders believe that EPC requirements should be strengthened and better harmonised between Member States. Harmonisation is also needed for financial institutions to facilitate the implementation of the European taxonomy.

- **Deep Renovation standard**

According to many respondents, a uniform definition, methodology or performance calculation, and target for defining ‘deep renovation’ should be established. This definition could be based on final energy and CO_2 savings, and facilitate the phase out of fossil fuels.

There is no consensus on whether deep renovation should be required through ‘one-step’ renovation to avoid the negative effects of staged renovation, or through a staged approach, grasping the low hanging fruits, in case building owners cannot afford deep renovation in one step.

A deep renovation standard should be included in the EPBD or EU taxonomy and linked to funding. Given the current long payback periods and the fact that targeted subsidies for deep renovation are not common across Europe, EU grants are needed. Other non-regulatory measures, such as technical assistance, consumer guidance, information campaigns, training, project financing are also required.

- **National long-term renovation strategies (LTRS)**

LTRS should be adapted to the higher EU ambitions. There is also a need to improve enforcement. Stakeholders suggest several measures: setting a target of 100% reduction of greenhouse gas emissions by 2050; being more closely linked to Article 5 of the EED; strengthening waste heat assessments (Article 15 RED) and including them into Article 2a; introducing a district-based approach. The LTRS should also take into account life cycle of buildings and replacement of the existing building stock by NZEB. Stakeholders suggest involving municipalities in drafting the LTRS, providing clear guidance on the role of citizen-led renovation programmes and including a communication plan for citizens. Member States should provide updated LTRS for 2030, including COVID-19 funding. The Commission should improve guidance to Member States and encourage best practices.

- **Nearly zero-energy buildings (NZEB)**

An ambitious definition and harmonised methodology for NZEBs should be introduced. Respondents suggest ensuring alignment with the Energy Efficiency First principle and that residual energy consumption is covered by RES; including requirements for the reduction of embedded emissions and addressing health, comfort and peak power demand. The public sector should lead the way. The deep renovation standard and MEPS should be designed to support the transformation of the EU building stock into NZEBs.

- **E-mobility**

According to some stakeholders, the EPBD should set higher EV charging requirements. Article 8 seems outdated in light of the projected increase in the market share of EVs in Europe for the coming years. The EPBD should ease access to private charging infrastructure, through more ambitious requirements for multi-unit buildings undergoing important renovation works, and through simplified procedures for the installation of charging points. Also, the EPBD should enable tenants and co-owners to install charging points in their homes. The EPBD needs to provide incentives for investments facilitating the installation of collective charging infrastructures, particularly in residential buildings.

- **Smart Readiness Indicator (SRI)**

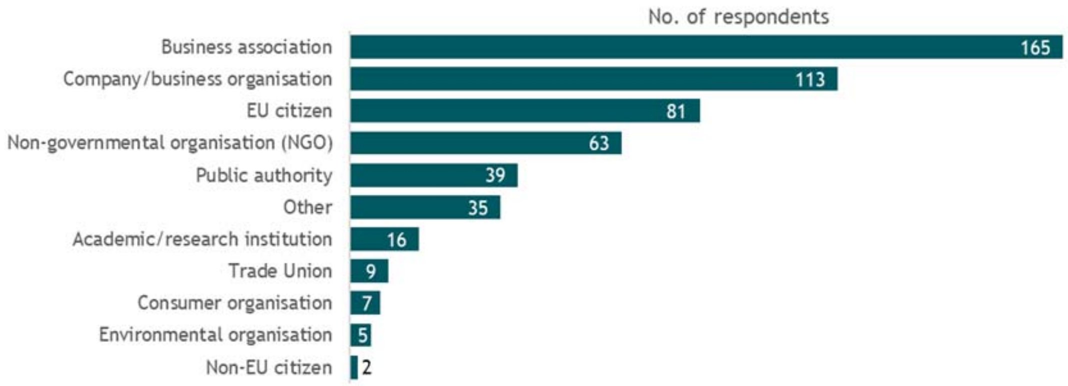
The SRI can be used to make building equipment comparable across Member States and helps to identify renovation needs. The SRI methodology should be simplified. The EPBD should establish a roadmap for the (voluntary) implementation of SRI and to accelerate its adoption.

2.2 Public Consultation questionnaire (30 March 2021-22 June 2021)

The PC included 32 questions via the EU Survey tool and 535 contributions were received. Most of the responses come from companies/business organisations and business associations (278 responses, 52%) and EU citizens (Figure B.2). 59 SMEs responded directly to the consultation, and several more were represented by associations or business organisations.

Stakeholder contribution to the PC was encouraged using social media and via the dedicated Commission webpage. The results of the PC were analysed using excel for the closed questions and Atlas.ti (text processing software) for the open questions.

Figure B.2: Stakeholder type - Public Consultation questionnaire



The questionnaire included open and closed questions. It was divided in three parts: 'Planning and policy instruments', 'Information provisions and energy performance certificates' and 'Enabling more accessible and affordable financing for building renovation'.

2.2.1 Planning and policies instruments

- **Mandatory Minimum Energy Performance Standards (MEPS)**

MEPS should be introduced (75%) and accompanied with proper funding and a solid financing framework. 78% of SMEs support this measure. MEPS should be linked to EPCs and BRP, focusing on worst-performing buildings and deep renovation. EU-wide MEPS are seen as a challenge due to MS differences. It was also indicated that mandatory MEPS should be introduced on the basis of a staged approach and linked to specific moments of a building life-cycle. The most important elements to a successful roll-out of MEPS are the availability of financial support to building owners, a stable legal framework, availability of adequate workforce capacity, correct identification of the worst-performing buildings and availability of emerging technologies.

- **Long Term Renovation Strategy (LTRS)**

The EPBD provisions on LTRS should be modified (61%). The ambition of the LTRS should be aligned with the new 55% emission reduction target for 2030 and climate neutrality by 2050. Their implementation should become a national priority, paying attention to affordability and social acceptance, with continuous revision (every 5 years), ensuring synergies with all related instruments (RED, EED), mainstreaming financing measures and inclusive financial strategies, targeting also indoor air quality and health & safety. The monitoring of the objectives identified by MSs in their LTRS should be strengthened (89%).

- **Zero emission buildings and deep renovation**

Zero emission buildings by 2050 should be defined in the EPBD (84%), to address also life-cycle emissions and facilitating the phase out of fossil fuels. The current definitions of NZEBs are not ambitious enough to contribute towards a fully decarbonised building stock (57%) and need to be more harmonised (67%). It would be beneficial to have a legal definition of deep renovation in the EPBD (68%). This definition should relate to both operational and embodied GHG life-cycle emissions, as well as broader aspects such as health and environmental standards, accessibility for persons with disabilities and climate resilience.

- **Inclusion of carbon emissions and climate change impacts**

The EPBD should include measures to report on whole life-cycle carbon emissions from buildings (68%) for all buildings and require that the likely impacts of climate change are taken into account in the planning of new buildings and major renovations (68%), particularly for new public and private buildings.

- **Electromobility**

Upgraded e-mobility provisions should apply to new non-residential (61%) and residential buildings (60%), and possibly refurbished (non-residential) buildings (53%). Requirements for installation of recharging points (65%), right to plug (for both tenants and owners) (62%) and inclusion of provisions for recharging points for vehicles other than cars (52%) are all necessary. Smart charging is considered key for grid stability. The promotion of public transport/active mobility or alternative technologies (e.g. hydrogen) was also raised.

2.2.2 Information provisions and energy performance certificates

- **Energy Performance Certificate (EPC)**

EPCs need to be updated and quality needs to be improved (65%). Quality improvement is key to assure owner/occupier's confidence (but also for the finance sector). A multiplication of tools has to be avoided, and the existing ones should be linked, such as the energy audit (of EED), BRPs which describe a building's deep renovation roadmap, and Digital Building Logbooks. Digital assets providing accessible real-time data should be considered. EPCs are considered as the main option to define MEPS. Improvements should be accompanied by measures enhancing the availability of qualified professionals, strengthening enforcement, controls and on-site visits. 71% of respondents think it is *very important* or *important* to improve control mechanisms, 76% of respondents state that harmonisation of EPCs is needed (76%). EPCs should provide information on energy performance (final and primary energy) and carbon emissions. The following aspects could also be introduced: demand-side flexibility, fire safety, comfort, Indoor Air Quality, Indoor Environmental Quality, ventilation, cost of energy, EVs, on-site renewables and storage. 68% of respondents think that EPCs should include further information on estimated energy and cost savings (68%). The validity of EPCs should be shortened.

- **Building Renovation Passport**

The Commission should clarify the scope of the BRP, then develop guidelines and best practice exchanges and make funds available for BRP development and implementation. A common EU template could be developed and the Commission could encourage tests in the Member States. BRPs should be deployed with digital logbooks informing on energy aspects, enabling data access to all relevant stakeholders. The link and interoperability with existing and potential tools such as EPCs, SRI and Digital Building Logbook should be ensured.

- **Building digitalisation**

Stakeholders think that the EPBD can contribute in making a wider range of building-related energy performance data available and accessible (73%). Some expressed the need for a structured approach to data collection, limiting administrative burden. Different tools, such as EPC, BRP, MEPS and SRI, may enrich data availability. Regarding the SRI, respondents suggest focusing on the implementation of SRI on a voluntary basis and developing links with other schemes.

2.2.3 Enabling more accessible and affordable financing for building renovation

Stakeholders think that the most important financial support mechanisms are direct grants to low-income citizens (73% think they are very important or important) and tax incentives (72%). There should be an attractive system of public subsidies, grants, low interest loans and tax incentives to stimulate deeper renovations across the EU. Measures such as EPC, BRP or MEPS should be linked to public financial incentives. The intensity of funding should be linked to the depth of the renovation (77%) and the level of energy performance, based on the EPC class achieved.

Public financial incentives should have a long-term vision and take into account vulnerable/low-income households. Other suggestions include support for energy service companies, energy performance contracting, earmarking part of the EU budget for building renovation. The most important policy measures addressing energy poverty that should be further reinforced are targeted financial support for lower and middle-income households and MEPS coupled with financing.

2.3 Stakeholder Workshops (31 March - 3 June 2021)

The workshops were designed to focus on specific topics relevant for the revision of the EPBD. The format facilitated an in-depth discussion and allowed for more direct stakeholder feedback on specific policy issues. Stakeholders which registered to the workshops received questions to be addressed during the workshops' sessions ahead of the workshop. Each workshop was centered around a dedicated topic and structured around 2-4 interactive sessions, which included also flash polls to gather participants' views .

Five workshops were organised, with an average of 242 registered participants.

Table B.1: Stakeholders' workshops

N°	Topic	Number of participants	Date
1	Setting a vision for buildings and a decarbonised building stock	258	31 March 2021
2	Minimum energy performance standards for existing buildings	301	15 April 2021
3	Strengthening buildings information tools (with a focus on EPC)	241	29 April 2021

4	Fostering the green and digital transition	220	19 May 2021
5	Accessible and affordable financing – energy poverty	190	3 June 2021

- **Workshop 1: setting a vision for buildings and a decarbonised building stock**

The workshop included 2 interactive sessions concerning *(1) new metrics for long-term decarbonisation* and *(2) prioritised EPBD provisions to be revised*.

The discussions were centred on the need for building decarbonisation, supported by clear metrics. In relation to carbon metrics and indicators the benefits of transparency, clarity and accountability were highlighted. Life-cycle based GHG metric received support by several participants. Several stakeholders stressed that MEPS for existing buildings are key, but that they should be open enough to allow for differences between MSs. In addition, certain stakeholders emphasised that the focus from now on until 2030 should be on implementing the last revision of the EPBD (from 2018).

- **Workshop 2: minimum energy performance standards for existing buildings**

The workshop included 3 interactive sessions concerning *(1) key elements to guarantee a successful roll-out of MEPS, (2) setting an appropriate intensity level* and *(3) first steps setting up a MEPS Scheme*.

Overall, most of the stakeholders support the introduction of MEPS with a clear timeline, goals and a long-term trajectory towards climate neutrality by 2050. However, several stakeholders pointed out that the reliability of EPCs needs to be strengthened. Stakeholders also pointed out that phasing is key: MEPSs should be defined as early as possible, leave time to scale up (at MS level), and establish clear intermediate objectives. There should also be some flexibility provided.

MEPSs should also be kept simple. They should not be overloaded with too many specific requirements, too hard and costly to enforce, or simply too difficult to be understood. Compliance should be based on transaction-related trigger points (sell and rent) and natural trigger points (e.g. planned renovation, end-of-life of fossil-based heating system).

- **Workshop 3: strengthening buildings information tools (with a focus on EPCs)**

The workshop included 3 interactive sessions on *(1) strengthening the information role of EPCs, (2) strengthening the quality of EPCs and (3) digitalisation* and *improving coverage of EPCs*.

In general, stakeholders expressed the view that the purpose and final use of EPCs need to be clearly defined. Stakeholders also raised the importance of focusing on improving the reliability of EPCs.

Many stakeholders raised the importance of EU level harmonisation of EPCs. Some stakeholders also promoted the idea of having EPCs which are tailored for specific target groups. Furthermore, according to several stakeholders, EPCs should provide personal recommendations, made by qualified experts. Overall stakeholders recommended digitalising EPCs, which would reduce their costs.

- **Workshop 4: fostering the green and digital transition**

The workshop included 4 interactive sessions concerning *(1) smart ready buildings, enablers to improve energy performance & decarbonisation and empower citizens, (2) Building Renovation Passport & digitalisation, (3)* e-*mobility & energy flexibility fostered by building codes* and *(4) data gathering & management*.

Some participants pointed out the need to improve provisions on inspection of heating systems and air-conditioning systems, in particular to tackle the issue of implementation and compliance. Other participants advocated for the gradual introduction of compulsory and harmonised SRIs. It was also mentioned that synergies should be explored between SRIs, EPCs and other certifications, and that smart systems should also improve the whole decarbonisation of the building, not only energy performance. According to several stakeholders, BRPs should be digital and have a connection to databases. Financial institutions should be involved in BRPs and get the data they need. BRPs should also include other aspects, such as indoor environmental quality.

Participants highlighted that the EPBD is particularly key for private/semi-private charging, but some stakeholders expressed the fear that focusing on transport could lead to losing focus on renovation. As regards e-mobility and charging, it was stressed that to accelerate the pace, (pre-)cabling (i.e. ducting) is key. There should be minimum requirements on functions and power thresholds.

- **Workshop 5: accessible and affordable financing – energy poverty**

The workshop included 3 interactive sessions concerning *(1) strengthening the EPBD, (2) enhancing financing for decarbonisation of the EU building stock,* and *(3) accessibility, social inclusion & alleviation of energy poverty.*

According to several participants, loans, tax incentives, etc. can complement (i.e. be blended with), but not replace subsidies.

Stakeholders stressed that tools need to be adapted to income levels, as decarbonisation is easier for higher income groups. It is necessary to ensure that the right framework is created so that low income groups, which may not access a loan, are included (i.e. reliance mainly or exclusively on grants for lower income groups). The importance of one-stop-shops (OSS), providing a trusted support to renovations for consumers, investors and retail banks, was also highlighted. ETS revenues were proposed as possible source of funding to alleviate energy poverty. It was also pointed out that *energy poverty* should be addressed rather as *general poverty*, and that renovations may also entail increases in rents.

Annex C: Who is affected and how?

SUMMARY OF COSTS AND BENEFITS

I. Overview of Benefits[6] (total for all provisions) – Preferred Option HIGH-I scenario		
Description	***Amount***	***Comments***
Direct benefits		
Reduced GHG emissions from heating, cooling and domestic hot water in buildings	98 Mt CO2 eq./yr or 23% by 2030 106.5 Mt CO2 eq./yr or 53.5% by 2050	Reductions/savings in the buildings sector compared to baseline scenario.
Reduced energy consumption from heating, cooling and domestic hot water in buildings	307 TWh/yr or 11.7% by 2030 686 TWh/yr or 34% by 2050	Reductions/savings in the buildings sector compared to baseline scenario
Reduced energy costs for consumers on heating, cooling and domestic hot water	EUR 20.3 billion per year or 8% by 2030 EUR 61.7 billion per year or 27.6% by 2050	Reductions/savings compared to baseline scenario. Buildings owners or tenants in the residential (households) and non-residential sector will be affected[7].
Indirect benefits		
Additional jobs created in EU	1.833 mn additional jobs or 1.2% low and medium skilled and 0.6% high skilled additional jobs by 2030 1.763 million new jobs or 1.2% low and medium skilled jobs and 0.7% high skilled jobs by 2050[8]	Compared to the baseline scenario. Most of additional new jobs created will be in construction, trade and services and industry (machinery, equipment, others) sectors. All these sectors are highly SMEs intensive since more than 90% of the EU companies from buildings construction sector, manufacturing of machinery and equipment and manufacturing of construction materials and glass are SMEs[9]. Loss of jobs will be in gas & heat industry (as anticipated, due to shift to clean energy).

[6] The benefits are "maximum effects". The degree they will be achieved depends to a large extent on specific implementing schemes at national levels.
[7] More precisely, this scenario will reduce the energy costs by 11% and 34% for residential consumers by 2030 and 2050 respectively. For non-residential consumers, the energy costs will increase by 4.5% but will decrease by 8% in 2030 and 2050 respectively.
[8] On top of the impact at the EU level, the scenario may generate on the worldwide supply chains some 805,000 and 890,000 additional jobs by 2030 and 2050 respectively. Out of these jobs about 22% is estimated to be created in the rest of European countries.
[9] According to Eurostat structural business statistics 2018 [sbs_sc_con_r2].

Additional value added created	EUR 104 billion per year or 0.9% additional value-added created by 2030[10]	Compared to the baseline scenario. Most of additional value-added created will be in construction, trade and services and industry (machinery, equipment, others) sectors. Loss of value-added will be in gas & heat industry (as anticipated, due to shift to clean energy).
Reduced air pollution	1.2% less SOx by 2030 5.9%, 1% and 0.8 % less SOx, NOx and PM respectively by 2050	Compared to the baseline scenario.
Impact on households expenditure	Estimate of about 11.5% and 35% reduction of household expenditure on electricity and heat by 2030 and 2050 respectively.	Compared to the 2020 baseline and for expenditure estimated in PPS (purchase power parity).
Impact on energy poverty	The two main indicators for energy poverty arrears on utility bills, inability to keep homes adequately warm are estimated to go down by 1.2% and 3.6% in 2030 and 2050 respectively.	Compared to the 2020 baseline.

II. Overview of costs – HIGH-I[11]					
		Consumers & Businesses		Administrations	
		One-off	Recurrent	One-off	Recurrent
MEPS1	Direct costs		Administrative costs: 288 M€/y (preliminary compliance checks)	Enforcement costs: 93.2 M€ (national IAs, update IT and forms, information campaigns)	Enforcement costs: 0.7 M€/y (compliance report to EC)
	Indirect costs	1M€ (adapt valuation standards to account for energy efficiency)	5M€/y (monitoring and update of valuation standards)		
MEPS2	Direct costs		Administrative costs: 696 M€/y (preliminary compliance checks)	Enforcement costs: 18.9 M€ (national IAs, dev. National scheme, reporting compliance to EC)	

[10] On top of the impact at the EU level, the scenario may generate on the worldwide supply chains about EUR bn 11.6 and EUR bn 13.5 by 2030 and 2050 respectively. Out of these, about 24%-25% is estimated to be generated in the rest of European countries.
[11] Administrative and enforcement costs are illustrated in more detail in Annex L.

	Indirect costs	92.2 M€$_{2020}$/y (additional average investment costs for renovation over period 2025-2030) 1M€ (adapt valuation standards to account for energy efficiency)	5M€/y (monitoring and update of valuation standards)		
BRP3	Direct costs		Administrative costs: 70 M€/y if subsidised and 278 M€/y without subsidy	Enforcement costs: 29.5-29.7 M€ (national & EC implementation) out of which 0.3-0.5 M€ for the Commission (develop common EU scheme and template)	
	Indirect costs	N/A	N/A	N/A	N/A
EPCSI3	Direct costs		Administrative costs: 1120 M€/y	Enforcement costs: 9.5 M€ (training & qualification, implementation)	
	Indirect costs	N/A	N/A	N/A	N/A
EPCQ3	Direct costs		Not considered to have significant costs additional to EPCSI	Enforcement costs: 5.4-8.1 M€ (increase quality control – scheme)	Enforcement costs: 9-90 M€ (increase quality control – additional checks)
	Indirect costs	N/A	N/A	N/A	N/A
EPCD3	Direct costs		Administrative costs: -0.3 M€/y (reduced person-hours work)		Enforcement costs: 4.2 – 9.6 M€ (running EPC database, inform public)
	Indirect costs	-0.3 M€ indirect savings (savings due to increased efficiency and access to data)			
SRI2	Direct costs		Administrative costs: -0.31 – 0.82 M€/y (additional costs to produce them)	Enforcement costs: 0.18 – 0.46 M€	
	Indirect costs	N/A	N/A	N/A	N/A
DEEP2	Direct costs	Not considered to have significant additional costs.	Not considered to have significant additional costs.	Not considered to have significant additional costs.	Not considered to have significant additional costs.

	Indirect costs	N/A	N/A	N/A	N/A
LTRS3	Direct costs	Not considered to have significant additional costs.	Not considered to have significant additional costs.	Enforcement costs: 4.1 M€ (additional LTRS reports) 0.5 M€ for the EC	
	Indirect costs	N/A	N/A	N/A	N/A
ZEB3	Direct costs		Not considered to have significant additional costs.	Enforcement costs: 2 – 8.1 M€ (adapting national legislation, establish LEVEL(S) framework)	Enforcement costs: 2.5 - 5 M€/y (implementing LEVEL(S) for new public buildings)
	Indirect costs	2.4 $M€_{2020}$/y (additional investment costs over period 2025-2030)			
EM3	Direct costs	Not considered to have significant additional costs.	Not considered to have significant additional costs.	Enforcement costs: 2.7 M€ (Legal feasibility study & implementation)	
	Indirect costs	EUR 11.1 billion until 2050 for ducting infrastructure (CAPEX, cumulated between 2020 and 2050) EUR 35.3 billion for recharging points (CAPEX, cumulated between 2020 and 2050)[12]			

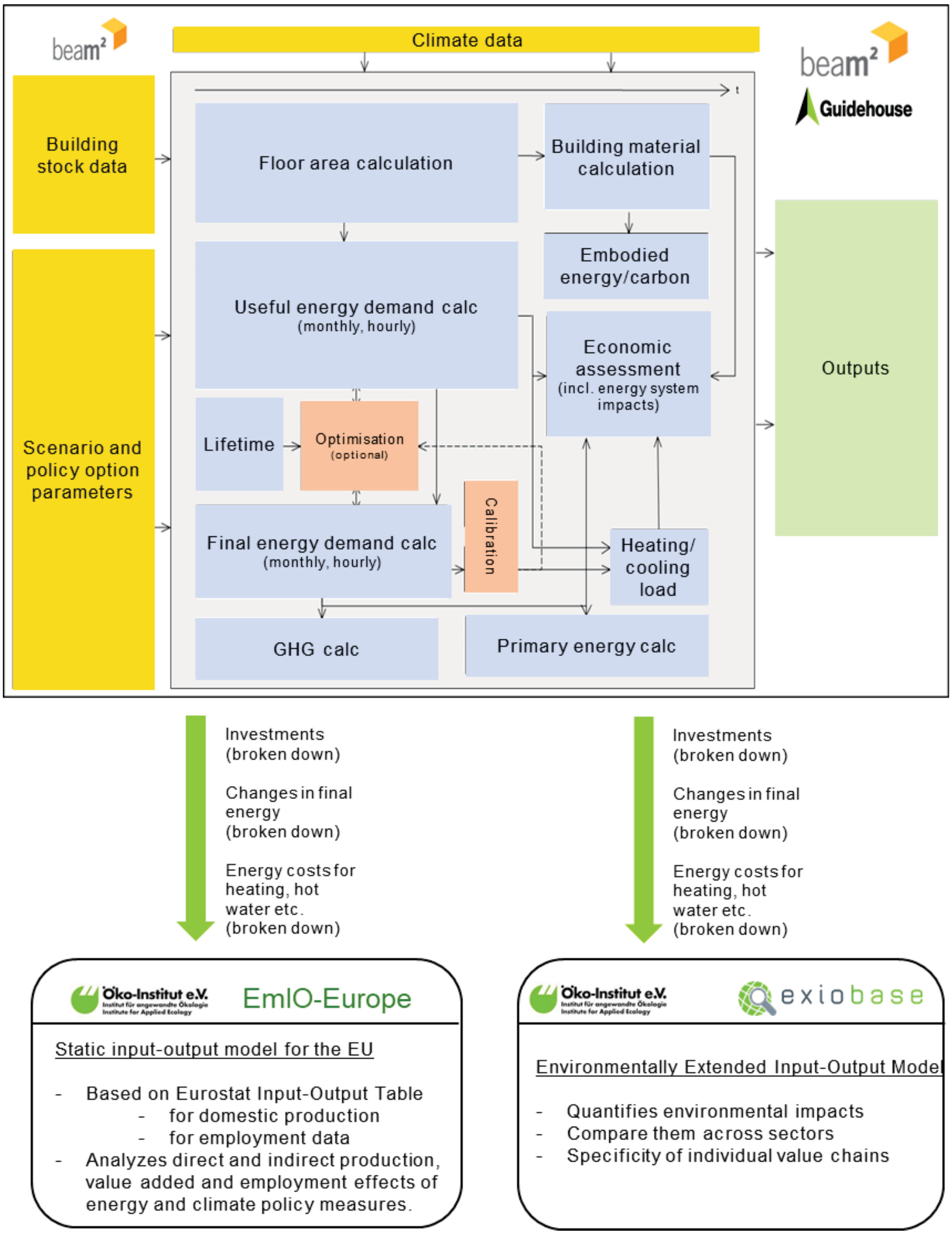
[12] Detailed explanations of the costs is provided in Annex I on e-mobility.

Annex D: Analytical methods

1. Overview of methodology and models used

The figure below illustrates the articulation between the different models used to assess the quantitative impacts of the policy options on key environmental, economic and social parameters.

Figure D.1: Overview of models



The assessment with the BEAM² model is clustered in five zones, covering all member states of the EU-27. Impacts of policy options and packages are calculated for each of these zones individually, since some key parameters (like climate, building stock etc.) differ significantly and therefore will be treated separately. The analysis with BEAM² is done in yearly time-steps until 2050.

Figure D.2: Reference zones for the EU

2. Built-Environment-Analysis-Model BEAM²

This section gives an overview on the methodology used for the ex-ante assessment of policy option, which is the BEAM² model.

beam²

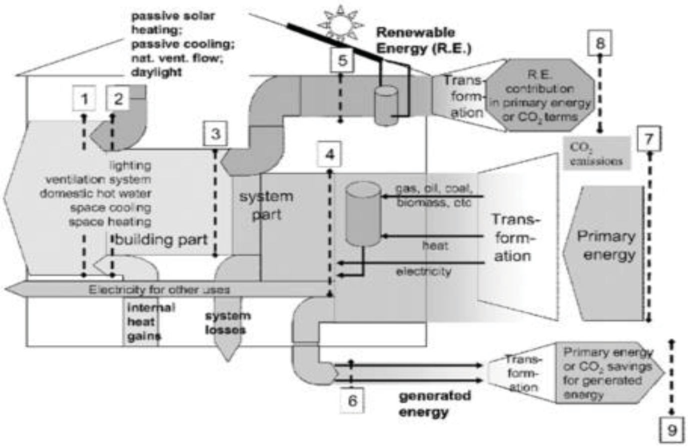
<u>Terms and Definitions</u>

As the **Built Environment Analysis Model BEAM²** model is set up in the framework of the European Energy Performance of Buildings Directive (EPBD), the general terms and definitions are aligned with it. The relevant document in that context is the umbrella document for all European standards within the EPBD, which is the Technical Report (TR): Explanation of the general relationship between various CEN standards and the EPBD, see

(CEN/TR 15615).[13] They are also valid for the energy demand calculations for space heating and cooling from (DIN EN ISO 13790)[14], which are also referred to.

Scope

Figure D.3: Schematic Illustration of the scope for the Built-Environment-Analysis-Model[15]



(1) represents the energy needed to fulfil the users requirements for heating, cooling, lighting etc, according to levels that are specified for the purposes of the calculation.

(2) represents the "natural" energy gains - passive solar heating, passive cooling, natural ventilation, daylighting ˝U together with internal gains (occupants, lighting, electrical equipment, etc)

(3) represents the building's energy needs, obtained from (1) and (2) along with the characteristics of the building itself.

(4) represents the delivered energy, recorded separately for each energy carrier and inclusive of auxiliary energy, used by space heating, cooling, ventilation, domestic hot water and lighting systems, taking into account renewable energy sources and co-generation. This may be expressed in energy units or in units of the energy ware (kg, m3, kWh, etc).

(5) represents renewable energy produced on the building premises.

(6) represents generated energy, produced on the premises and exported to the market; this can include part of (5).

(7) represents the primary energy usage or the CO2 emissions associated with the building.

The general references for the energy-related calculations are (CEN/TR 15615) and a report by Boermans et al.[16] The calculation methodology follows the framework set out in the relevant Annexes to the EPBD. For useful heating and cooling demand calculations the

[13] CEN/TR 15615. Technical Report - Explanation of the general relationship between various European standards and the Energy Performance of Buildings Directive (EPBD) - Umbrella Document, CEN April 2008 (English).

[14] DIN EN ISO 13790. Energy performance of buildings - Calculation of energy use for space heating and cooling (ISO 13790:2008), Beuth Verlag Berlin 1999 (German version EN ISO 13790:2008).

[15] BEAM2 (CEN/TR 15615)

[16] Boermans, Thomas, Kjell Bettgenhäuser, Andreas Hermelink, and Sven Schimschar. May 2011. Cost optimal building performance requirements - Calculation methodology for reporting on national energy performance requirements on the basis of cost optimality within the framework of the EPBD, Final Report, European Council for an Energy Efficient Economy eceee, Stockholm (English).

methodology in EN ISO 13790 (DIN EN ISO 13790) allows a simplified monthly calculation based on building characteristics. It is not dependent on heating and cooling equipment (except heat recovery) and results in the heating energy that is required to maintain the temperature level of the building. The calculations are based on specified boundary conditions of indoor climate and external climate, which are also given on monthly basis. Based on that energy demand, the delivered energy (final energy) for heating, cooling, hot water, ventilation and lighting if applicable are calculated per fuel type. In a last step the overall energy performance in terms of primary energy and CO_2 emissions is calculated. An overview of the calculation process is given in the following Figure which is based on CEN/TR 15615. Energy flows are to be followed from the left to the right. The three steps of the energy performance calculation are always done for reference buildings for a sector, age group, renovation level and HVAC systems. Subsequently the energy costs per year and the investment costs in case of a new buildings or renovation are calculated.

Structure and methodology

The basic model setup and calculation process is shown in the figure below. It is based on the energy demand calculations for space heating and cooling from the ISO Standard 13790:2008 (DIN EN ISO 13790). As all calculations are executed for a highly disaggregated building stock with all its characteristics, the following description of the methodology and calculation process applies for all sub-segments of the building sector within the model.

Basic input to the model are data on the building stock such as building types, floor area, age groups, renovation levels, HVAC systems in stock and population. Furthermore, the climate data such as temperature and irradiation is required. Based on this data a status-quo inventory of the building stock can be constructed.

For the scenario analysis as central part of the model, additional input data with respect to population forecast, GDP development, new building, demolition and renovation activities, thermal insulation standards, heating, ventilation and air conditioning equipment, renewable energy systems and energy efficiency measures is required. Furthermore, energy costs, cost for energy efficiency measures at the building envelope and costs for heating, cooling and ventilation systems and renewable energy systems together with increase rates and discount rates are processed. With respect to the overall energy performance, the greenhouse gas emissions factors and primary energy factors are required per fuel type and GHG emissions for energy efficiency and HVAC systems.

The calculation process over the scenario time frame is organised as follows. Based on the initial floor area distribution along the reference buildings (RB), age groups (AG), renovation levels (RL), heating systems (HS)[17], hot water systems (DHW)[18] and cooling systems (CS) a

[17] Heating systems (HS) also include ventilation systems (VS) and solar thermal systems (STS) for HS support if applicable.
[18] Hot water systems (DHW) also include solar thermal systems (STS) for hot water if applicable.

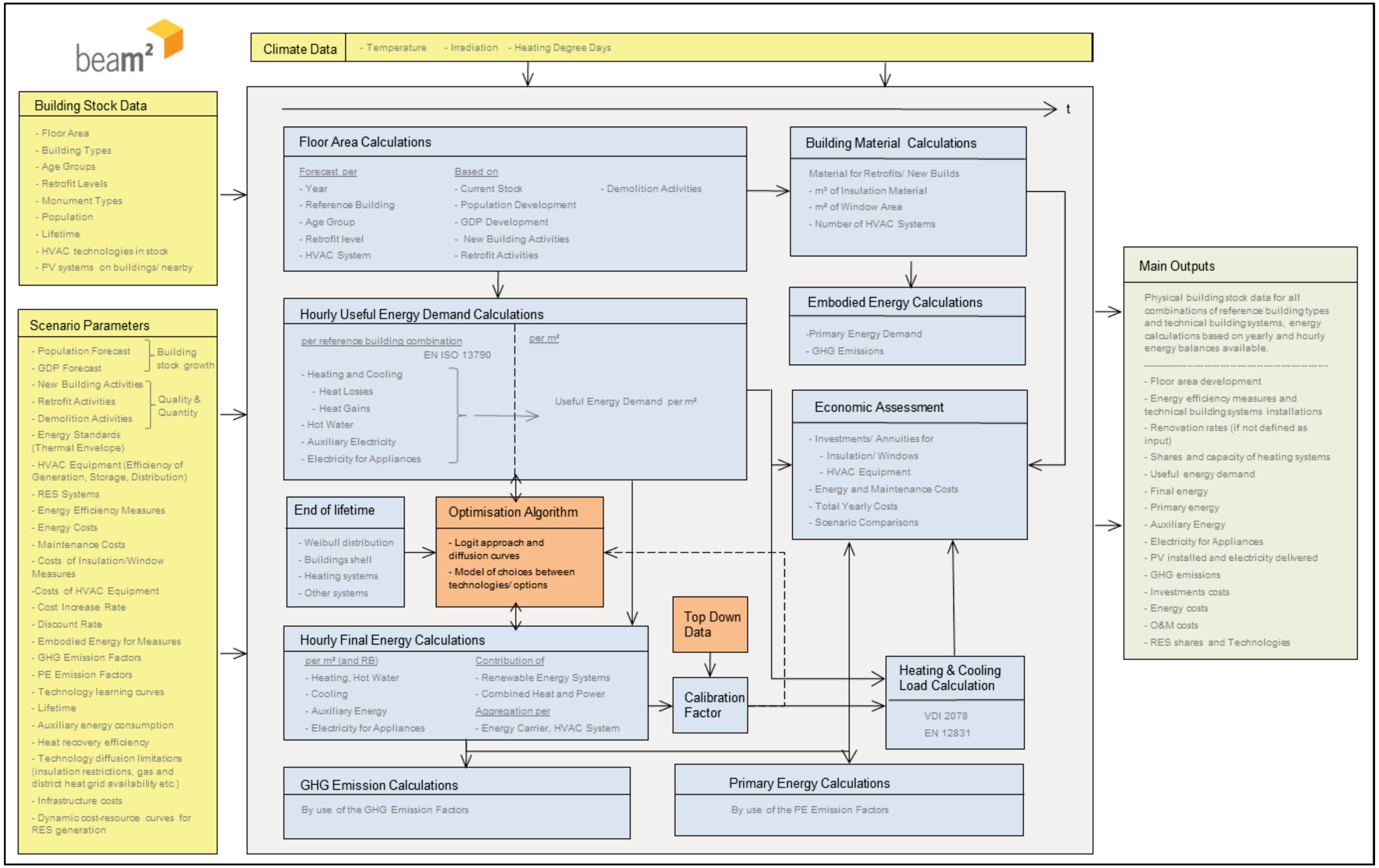
forecast for the floor area is done taking into account new building, demolition and renovation programs for all or parts of these combinations. All activities in year i have an effect starting in year i+1.

The useful energy demand for heating and cooling is derived from an integrated calculation algorithm based on (DIN EN ISO 13790). The energy demands for hot water, auxiliary energy and electrical appliances if applicable are also derived. The final energy is calculated based on the parameters of the HVAC systems.[19] The aggregated final energy for heating can be compared to top-down data. In this case a calibration factor is calculated, which can be applied to the final energy for heating.

The delivered energy together with the primary energy and GHG emission factors are combined to the overall primary energy and GHG emissions. For the economic assessment heating and cooling loads per single building type are derived, which are relevant to the systems sizes and investment costs. The economic evaluation takes beside the investment costs also the energy costs into consideration. In addition to the above described output, the embodied energy and primary energy for all energy-related components (efficiency and HVAC systems) are quantified in the model based on the total volumes of insulation, area of windows and number and power of HVAC equipment.

[19] The final energy is equal to the delivered energy plus energy produced in or on the building by solar or wind systems.

Figure D.4: General structure of the Built-Environment-Analysis-Model BEAM2



Scenario Results

The main outputs of the model are the floor area developments for reference buildings (RB), age groups (AG), renovation levels (RL) heating (HS), hot water (DHW), and cooling systems (CS) in the first place. The next step is the calculation of the useful energy demands for heating, cooling and hot water. From this the final energy/ delivered energy for heating, cooling, hot water, ventilation and auxiliary energy is derived. For the overall energy performance, the greenhouse gas emissions and primary energy is been calculated. For the economic evaluation energy costs per year are provided as well as investment costs in new buildings and renovation. In order to compare yearly costs, the investments are broken down along the lifetime of components to yearly costs by use of annuities. All results are given in specific units (e.g. per m^2) and for the overall building stock in the respective scenario.

Input Data

Input data to the model describes the current building stock as status-quo. This is e.g. the floor area distribution and the definition and specifications of reference buildings (RB), age groups (AG), renovation levels (RL) and HVAC systems such as heating (HS), hot water (DHW), solar thermal systems (STS), ventilation systems (VS) and cooling systems (CS).

For the analyses it is necessary to investigate the typical construction characteristics of the considered building types, e.g. size, geometries, insulation level by regulation, typical HVAC equipment (space heating system etc.), kind and size of windows, orientation etc. A good source for this task is the TABULA webtool[20] which provides detailed reference building data for up to 20 European countries, differentiated between residential building type and age class. The national cost-optimality reports from EU Member States also provide useful information for different residential and non-residential buildings[21].

More general examples for European reference buildings are provided in the FP7 project iNSPiRe[22], especially in its report D2.1a. Specifically for non-residential buildings, a number of reference buildings can also be found in Schimschar et al. (2011) "Panorama of the European non-residential construction sector"[23].

---

20 http://episcope.eu/building-typology/webtool/
21 https://ec.europa.eu/energy/en/topics/energy-efficiency/buildings
22 http://inspirefp7.eu/about-inspire/
23 http://www.leonardo-energy.org/sites/leonardo-energy/files/documents-and-links/European%20non-residential%20building%20stock%20-%20Final%20Report_v7.pdf

For the definition of representative HVAC and BACS configurations in the reference buildings, relevant information can be found in EPISCOPE's scientific reports[24], PRODCOM[25], data from ECODESIGN LOT 33 "Preparatory study on Smart Appliances"[26], the ZEBRA data tool[27], the ENTRANZE data tool[28], EUBAC[29] and the former BPIE's data hub for the energy performance of buildings which migrated and improved in the form of current EU Building stock observatory[30].

The following disaggregation of the building stock for the residential and non-residential building sector per age class and subcategory is applied:

- Residential buildings
  - Single family houses (SFH)
  - Multi-family houses (MFH)
    - Small multi-family houses
    - Large multi-family houses
- Non-residential buildings
  - Office Buildings (OFB)
  - Trade and Retail Buildings (TRB)
  - Education Building (EDB)
  - Touristic Buildings (TOB)
  - Health Buildings (HEB)
- Other Non-residential Buildings (ONB)Age groups:
  - Pre 1945
  - 1945-1970
  - 1971-1990
  - 1991-2013
  - From 2014[31].

As basis for all scenarios, the baseline defines the development of the building stock structure until 2030 and until 2050. For characterising the current and future building stock the following new construction and renovation target levels have been used to identify different level of efficiency of the building shell:

---

[24] http://episcope.eu/building-typology/country/
[25] http://ec.europa.eu/eurostat/web/prodcom
[26] http://www.eco-smartappliances.eu/Pages/welcome.aspx
[27] http://www.zebra-monitoring.enerdata.eu/
[28] http://www.entranze.eu/tools/interactive-data-tool
[29] http://www.eubac.org
[30] https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/eu-bso_en
[31] A more detailed description of the BEAM² model is available in Bettgenhäuser, K. (2013). Integrated Assessment Modelling for Building Stocks - A Technical, Economical and Ecological Analysis. Dissertation TU Darmstadt D17, Ingenieurwissenschaftlicher Verlag 2013.

- Renovation levels
    - reno-average
    - reno-zeb partial from not renovated
    - reno-zeb partial from already renovated
    - reno-zeb restricted
    - reno-zeb
- New construction levels
    - new-nzeb standard (current NZEB)
    - new-zeb

In addition, two status quo levels, characterising buildings of the current stock ('not renovated' and 'already renovated') determine the starting level in terms of energy need for the scenario calculations.

Example of a renovation of a single family building (Western Zone)

This box provides an example building stock calculation of renovations on the basis of a single building. For this purpose this excursus shows exemplary calculations for a representative single-family house from 1945-1990 in the Western Zone[32].

Example building in Western Zone, source: TABULA[33]

The chosen "not renovated" building with a floor area of 126 m² belongs to the category of the worst-performing building of energy class F and will be renovated either to the *"reno zeb partial from not renovated"* or *"reno zeb"* standard. The *"reno zeb partial from not renovated"* represents the first step of a potential building renovation passports (BRP) lifting the building from energy class F to D. And the *"reno zeb"* standard shall represent the final future renovation status of the BRP.

The following table shows the calculated impacts for space heating on energy, emissions and costs without replacing the heating system.

Parameter	Not renovated	Reno zeb partial from not renovated	Reno zeb	Unit
Energy need	175	145	18	kWh/m²a
Final energy	241	200	25	kWh/m²a
Primary energy	265	220	27	kWh/m²a
GHG emissions	49	40	5	$kgCO_2/m^2a$
Investments[34]	-	84	212	Euro/m² floor area
Energy costs[35]	24	20	2.5	Euro/m² floor area

The table shows moderate reductions for the first step of the BRP when renovating the upper and cellar ceiling only (appr. -17%). Significant savings of about -90% can be achieved in a second step when the walls and windows are brought to passive house standard[36] as well.

[32] Western Zone: accounts for appr. 50% of the EU residential floor area; SFH: accounts for appr. 70% of residential floor area in the Western Zone; 1945-1990: accounts for appr. 50% of SFH floor area in the Western Zone.

[33] Institut für Wohnen und Umwelt (IWU) 2015.

[34] Investments include additional costs for the second retrofit step *"retrofit zeb"* (wall and window retrofit only) after the first step with the *"retrofit zeb partial from not renovated"* (upper and cellar ceiling only).

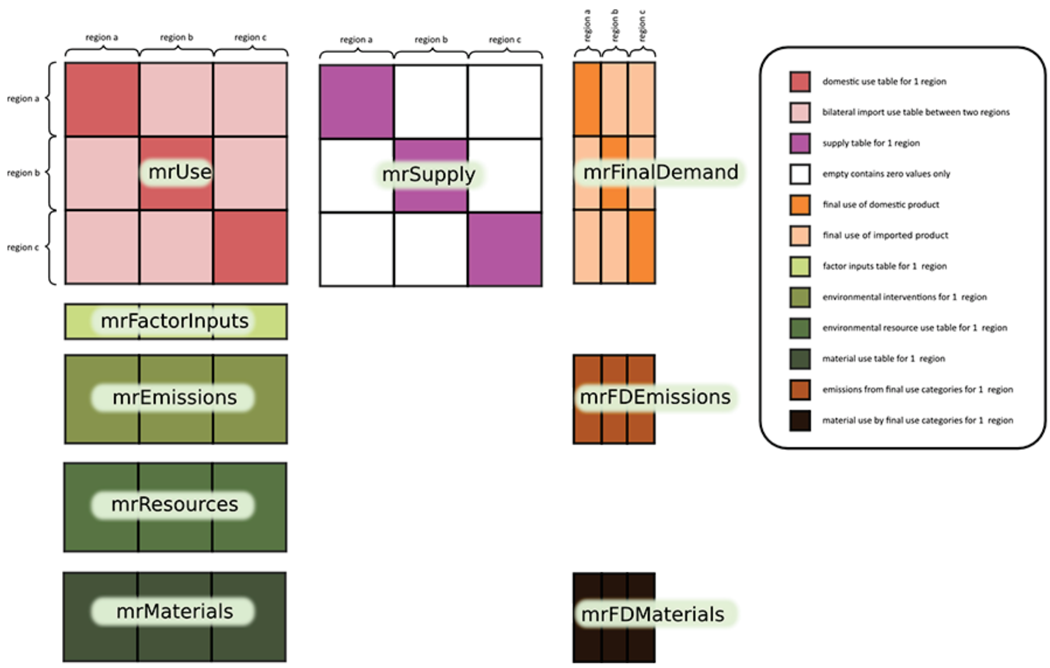
[35] Averaged energy price for gas from 2020 to 2050 is about 0.10 Euro/kWh.

[36] EnerPHIT standard according to Passive House Institute (PHI).

3. Exiobase Model for Environmental Impacts - multiregional, environmentally extended Input-Output model (Exiobase)

Environmentally Extended Input-Output (EEIO) tables can be used to quantify environmental impacts and compare them across sectors, as they allow for a sectoral allocation of different environmental impacts while taking into account the specificity of individual value chains. In this project, the multiregional input-output (MRIO) database EXIOBASE has been used used (Tukker et al. 2013; Wood et al. 2015; Stadler et al. 2018).

Figure D.5: Overview of Exiobase model[37]



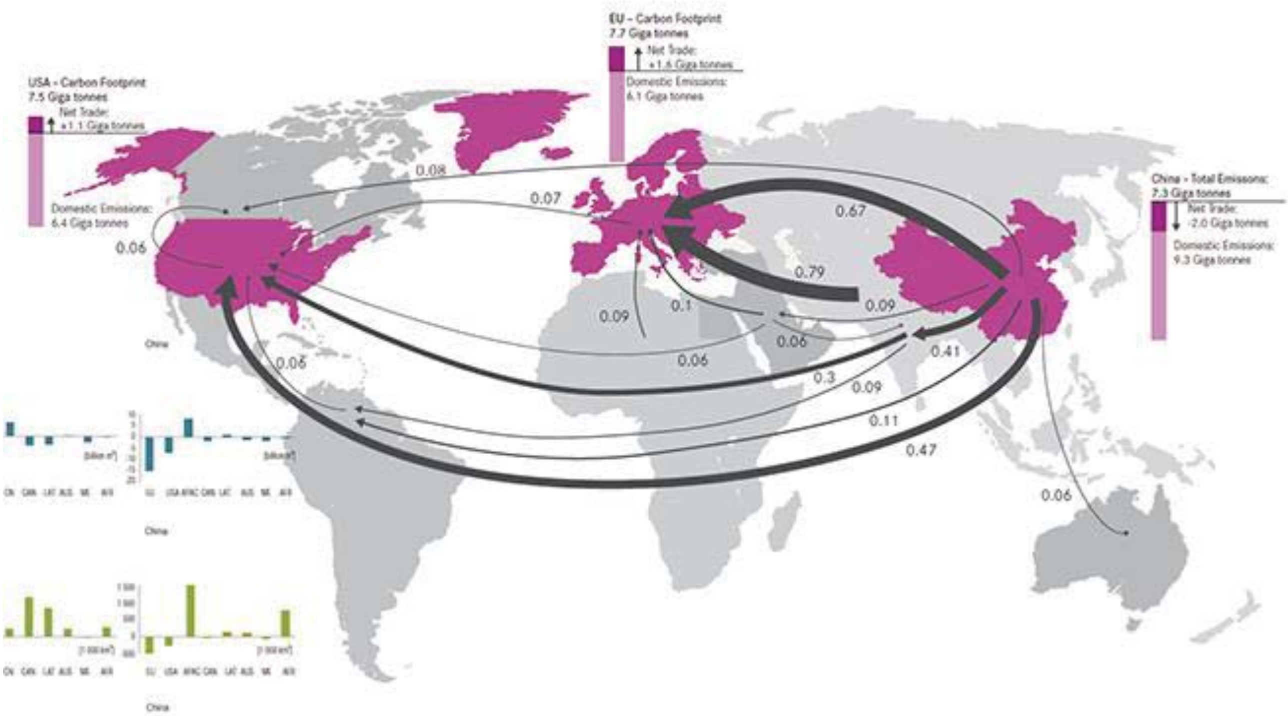
Input-output databases map the supply relationships between economic sectors and from them to final demand (consumption, investment, etc.). Multiregional versions relate the economic and final demand sectors of individual countries or world regions to each other and thus allow the consideration of complex international supply chains. The current version (v3) of EXIOBASE[38] divides the global economy into 45 countries and distinguishes between 163 industries and 200 product groups.

With the help of detailed environmental extensions, resource consumption and environmental impacts of individual economic sectors (manufacturers of the 200 different

[37] Source: Baartmans, Ruud (o. J.), EXIOBASE Multi-Regional Supply and Use Tables. https://exiobase.eu/index.php/2-uncategorised/29-exiobase2-mr-sut
[38] https://zenodo.org/record/4277368

product groups) can be determined. Intermediate inputs are included, even if they are produced abroad (for the structure of EXIOBASE, see Figure below). For example, in the building sector, resource consumption in the case of a renovation occurs not only by the use of bitumen and other material, but also, for example, through the use of the energy and infrastructure. These inputs from other sectors of the economy to the building sector are necessary for it to provide its services. According to this logic, the resulting environmental impacts are attributed to the demanding sector.

Figure D.6: Example showing the outputs of Exiobase[39]



---

39 Extracted from Exiobase.

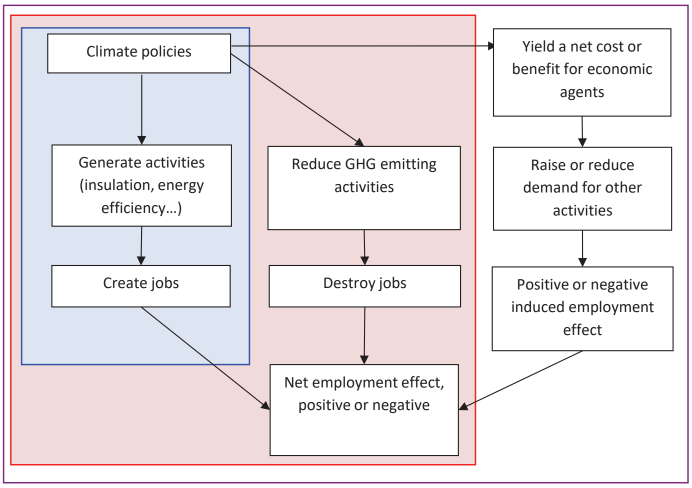
4. EmIO-Europe Employment I/O Model (EmIO-Model)

EmIO is a static input-output model for the EU based Eurostat Input-Output Table for domestic production at basic prices as well as Eurostat employment data. It includes 59 NACE sectors for the EU. The model analyses direct and indirect production, value added and employment effects of energy and climate policy measures.

EmIO Europe provides a transparent and easy-to-use tool for understanding linkages between different parts of the economy. It has the advantage of i) providing direct and indirect effects; ii) giving a relatively high resolution of sectoral detail (for the EU: NACE Rev1.1 59 2-digit sectors, higher resolution in NACE Rev.2); iii) input-output and employment data being readily available; iv) medium degree of complexity; v) simple relationships (Leontief production structure for production sectors).

The model distinguishes three effects: a) direct production and employment effects triggered by investments or production activities in certain sectors, b) indirect production and employment effects induced in upstream production stages by these increased investment or production activities, c) production and employment effects due to changes in demand (quantity and structure) resulting from the need to counter-finance investments or to create higher revenues that are passed on to stakeholders.

Figure D.7: Economic mechanisms exemplified for employment effects[40]



In order to make use of the model, information on both investment and operation and maintenance (O&M) activities induced by the policy options are required and needs to be assigned to sectors within the Input-Output model. This includes information on increased investment and O&M activity stimulated by the policy option in some areas (blue box) as well as information on decreased activity due to the policy option in other

[40] Guidehouse (2021).

sectors (red box). In case information is provided on a more detailed level, the data needs to be aggregated in accordance with the sectoral aggregation level of the input-output statistics. In the process of aggregation, some activities may need to be assigned to one and the same sector (e.g. machinery and equipment or services relating to maintenance and repairs) and information on positive and negative stimulation and their individual effects on employment may no longer be disentangled. The overall net effect is then assessed on that basis.

It is important to account for the fact that economic agents (households, businesses, governments) will necessarily pay for the potential extra costs induced by the policy option and will therefore reduce other expenses, thus potentially inducing a negative effect on output and employment. Taking into account this "income effect" requires some additional assumptions, notably relating to which economic actors will bear the extra costs and how they will change their saving and consumption in response to these extra costs. EmIO Europe can distinguish whether the cost of the policy or measure is borne by consumers, by industry or by the government.

5. Definition of the baseline and coherence with the "Fit for 55" baseline

A baseline has been defined for the assessment of the impacts of the policy options for the EPBD revision. The policy options have been compared against this baseline to determine their impacts across key indicators.

The baseline considers the current regulatory framework. To ensure alignment with the baseline and point of departure of analysis of the other "Fit for 55" initiatives, key assumptions on the energy systems and on policy from the Reference scenarios 2020[41] have been adopted also in BEAM and EmIO-Model. The adoption of the same assumptions ensures that while for the revision of the EPBD the analysis is focused on impacts on the building stock only, the key parameters related to the business as usual development of the energy system in the 2020-2050 timeframe are aligned with the other "Fit for 55" initiatives.

In particular, to ensure consistency and comparability, the following assumptions have been aligned to the Reference scenario 2020:

- Energy prices
- Population data
- Gross Domestic Product
- Carbon content of electricity supply and district heating (both for baseline and policy scenario aligned with "Fit for 55")
- Heating and cooling degree days data

[41] EU Reference Scenario 2020 | Energy (europa.eu)

Policy intensity has also been assumed in accordance to the Reference scenarios 2020 for what concerns the achievement of the 2030 energy efficiency and renewable goals, and the reduction of greenhouse gas emissions by 2030 and 2050.

6. Impact Categories

An overview of the impact categories used for the assessment is provided in Figure D.8.

Figure D.8: Overview of impact categories, methodologies, and indicators

<u>Impacts on the building stock performance</u>

Impacts of the building stock performance include all physical indicators and parameters of buildings, such as building types, age groups, renovation levels, efficiency of components (walls, windows, roof, ceilings etc.), technical building systems (e.g. heating and hot water systems, cooling systems, ventilation systems), smart readiness of buildings etc. physical parameters of the building stock until 2050 will be determined on a yearly basis. Renovation rates and depth regarding energy efficiency and renewable energy measures are fully reflected by the model.

<u>Renovation rates</u>

Currently there is no univocal way to define renovation rates but several main approaches to represent the transformation of the building stock and its improvement in energy performance exist, such as:

a) Floor area approach, i.e. the ratio between the floor area renovated in a given year or over a period and the total floor area of the building stock;
b) Energy savings approach (either in primary or final energy), i.e. the ratio between the energy savings in a given year or over a period and the total energy consumption;
c) Emission savings approach, i.e. the ratio between the emission savings in a given year or over a period and the total emissions of the building stock.

Furthermore, there are also two main approaches in calculating the rate:

- As a ratio between floor area, energy or emission savings in a given year reported to the corresponding total floor area, energy or emission savings of the building stock to be renovated in the base year (fix denominator over time);
- As a ratio between floor area, energy or emission savings in a given year reported to the total floor area, energy or emission savings of the building stock in the same given year, taking also into account the new construction and demolition (variable denominator over time).

It has become more common to present the renovation rates as a ratio of the renovated floor area. This approach appears to be straightforward and easy to understand, but has some drawbacks which need further consideration.

Firstly, and as shown in a renovation study[42], floor area based renovation rates are not necessarily linked to the energy savings actually achieved. As a consequence, floor area based renovation rates don't provide a clear image of the energy and emission savings achieved without additional information on renovation depth.

Secondly, the consideration of staged renovations introduces the possibility of double counting when applying a floor area based approach. For example, a building renovation passport could define five steps towards achieving a performance corresponding to NZEB or ZEB level. In this case, each renovation step would be counted separately and the floor area of this building would count as renovated five times within the time interval of its renovation plan. To overcome this issue, a 'normal' renovation depth can be defined, that is used to normalise all other renovations having a renovation depth

[42] Esser et al. 2019, Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU.

different from that. This 'normal' renovation is also called 'renovation equivalent'. Typically a 'deep' renovation is taken as 'normal'.

The (b) energy and (c) emission savings approach to represent renovation rates have the advantage of showing immediately the impact of renovation measures on energy consumption and emission and of avoiding double counting in case of stage renovation. On other hand, they fail to provide an indication on floor area (buildings) affected by the renovation.

The BEAM modelling would allow for all the above representations of renovation rates, but for the purpose of this Impact Assessment, renovation rates are calculated on the basis of the renovated floor area, presented in conjunction with annual energy savings and GHG emissions reductions.

In this Impact Assessment, the renovation rates are calculated based on annual share of the renovated floor area, distinguishing different renovation levels used in the model:

- reno-average
- reno-zero-energy emissions (zeb) partial
- reno-zeb partial
- reno-zeb restricted
- reno-zeb

The above renovation levels are associated to the improvements of building envelope presented in table D.1.

Table D.1: Building envelope efficiency per reference zone and renovation level [W/m²K]

Building shell component	EU reference zone				
	Northern	Western	North-Eastern	South-Eastern	Southern
reno-average*					
Wall	0.24	0.26	0.24	0.27	0.76
Window	1	1.47	1.24	1.14	3.71
Floor	0.31	0.28	0.32	0.3	0.64
Roof	0.15	0.19	0.16	0.25	0.68
reno-zeb partial from not renovated**					
Wall	*Depend on the respective „not renovated" initial level.*				
Window	*Depend on the respective „not renovated" initial level.*				
Floor	0.28	0.36	0.28	0.36	1.2
Roof	0.1	0.12	0.1	0.12	0.4
reno-zeb partial from already renovated					
Wall	*Depend on the respective „already renovated" initial level.*				
Window	*Depend on the respective „already renovated" initial level.*				

Floor	0.28	0.36	0.28	0.36	1.2
Roof	0.1	0.12	0.1	0.12	0.4
reno-zeb restricted					
Wall	0.24	0.26	0.24	0.27	0.76
Window	0.65	0.85	0.65	0.85	1.25
Floor	0.28	0.36	0.28	0.36	1.2
Roof	0.1	0.12	0.1	0.12	0.4
reno-zeb* **					
Wall	0.14	0.18	0.14	0.18	0.6
Window	0.65	0.85	0.65	0.85	1.25
Floor	0.28	0.36	0.28	0.36	1.2
Roof	0.1	0.12	0.1	0.12	0.4

** In addition to the indicated U-values, heat bridges of 0.10 W/m²K are considered in the "reno-average" level*
*** In addition to the indicated U-values, heat bridges of 0.05 W/m²K are considered in the "rreno-zeb" levels.*
**** Automatic shading devices (except in zone N) are included in the "reno-zeb" level.*

In order to mitigate the impact of staged renovation, renovation rates are presented as average floor area renovated over a 5 years period and highlighting the average share of renovated area to "deep renovation" levels (as currently understood) over the same period of time. Although not perfect, the average renovation has the advantage of approximating the staged renovations into a full renovation equivalent, being calculated over a 5 years period as the ratio between the difference of the total renovated floor area in the two years defining the time interval at numerator and the average total floor area of the building stock in same two years at denominator.

The average rate of deeply renovated floor area after 2020 indicates the evolution of the buildings floor area renovated at deep renovation levels in total renovated floor area. It is calculated in a similar way to the average renovation rate, i.e. over a 5 years period and as the ratio between the difference of the total deeply renovated floor area in the two years defining the time interval at numerator and the average total renovated floor area of the building stock in same two years at denominator. The deeply renovated floor area in a year is the sum of floor area renovated at renovation zero emission (zeb) partial, renovation zeb partial, renovation zeb restricted, renovation zeb. Total renovated floor area is the sum of the renovated floor area at any renovation depth, i.e. including also renovation average. The average renovation rate and average rate of deeply renovated floor area in the considered scenarios are presented in the following table.

Table D.2: Average renovation rate and average rate of deeply renovated floor area in the considered scenarios

	2020	2025	2030	2035	2040	2045	2050
Average renovation rate in full renovation equivalent (over 5 yrs) [%total floor area]							

BSL	1.35%	1.47%	1.65%	1.72%	1.72%	1.72%	1.71%
LOW	1.35%	1.47%	1.85%	2.06%	2.06%	2.05%	2.05%
MODERATE	1.35%	1.47%	1.83%	2.01%	2.01%	2.23%	1.74%
HIGH-I	1.35%	1.47%	2.99%	3.60%	3.34%	2.29%	0.93%
HIGH-II	1.35%	1.47%	2.99%	3.60%	3.34%	2.29%	0.93%
Average share of deeply renovated floor area after 2020 (over 5 yrs) [% of total renovated area]							
BSL	1.0%	1.2%	1.4%	1.7%	2.0%	2.2%	2.6%
LOW	1.0%	1.2%	1.4%	1.6%	1.9%	2.2%	2.5%
MODERATE	1.0%	1.2%	1.6%	3.3%	6.0%	9.6%	10.8%
HIGH-I	1.0%	1.2%	3.9%	18.9%	39.6%	53.6%	59.2%
HIGH-II	1.0%	1.2%	3.9%	18.9%	39.6%	53.6%	59.2%

Impacts on energy consumption and GHG emissions

The impacts on energy consumption and consequently GHG emissions are determined by the development of the physical building stock over time. All energy flows within buildings and associated GHG emissions in the short, medium, and long term are covered by the BEAM² model. Final energy and primary energy will be modelled and reported in kWh, while the GHG emissions are expressed in t of CO2.

Environmental impacts

Environmental impacts induced by policy options or policy packages go beyond greenhouse gas emissions and might include the use of materials, land, water but also impacts on air pollutants and other categories. It is important to note that these impacts not only occur through changes in production or consumptions patterns within the EU but also in other countries that produce products or materials imported into the EU.

To assess such global environmental impacts, the *multiregional Exiobase input-output model has been used*. The model is built upon the multiregional environmentally extended Exiobase database 3 (https://exiobase.eu/) and provides information on a wide set of environmental indicators in about 45 countries and more than 150 sectors. The approach is particularly suitable for measuring environmental impacts in the context of international value chains, as they depict the interrelations of the global economy in detail and thus allow considering footprints of domestic production and environmental impacts occurring abroad. It thus provides a consistent framework for quantitative indicators that capture direct and indirect emissions.

Model inputs to Exiobase input-output model will be provided by the BEAM² model and the micro-economic analysis. They include:

- Investment costs broken down by different types (equipment and installation) and sectors (e.g. building sector, HVAC-systems, financing costs)
- Changes in EU final energy demand and costs for heating, hot water, cooling, auxiliary and lighting for the relevant time frame

The model runs in a comparative static way. This means that economic structures are kept constant over time. The reason for this is that changes in productivity and production patterns outside the EU are not known and cannot be simulated with reasonable certainty. Rather than applying a series of uncertain assumptions on elasticities of substitution and future development for production sectors around the world, a framework built on known input-output coefficients is applied.

Micro-economic impacts

Micro-economic impacts include effects on investment, energy expenditure, operation and maintenance costs, compliance and administrative burden, income, information and knowledge, access to housing and markets and potentially other factors that are relevant for decision making or operation. The extent and kind of impacts differ by operators or stakeholders, e.g. manufacturers, installers, retailers, Member State authorities, consumers. Some impacts directly affect stakeholders while others have indirect effects through changes in prices, technology, or availability. Data on investment broken down by different types (equipment and installation) and sectors (buildings sector, HVAC-systems, financing etc.), on energy expenditure (by technology and application) as well as operation and maintenance cost will result from the BEAM² model.

Macro-economic impacts

Macro-economic impacts relate to consequences of policy options or policy packages for economic growth and employment. They can further relate to conditions for investment and functioning of markets as well as stabilization of markets.

Relevant economic effects of the identified policy options or policy packages can be foreseen in demand, production output, value added and employment for sectors both directly and indirectly affected by the policies. Direct effects will be seen in sectors relating to buildings insulation and heating technologies, e.g. construction sector and its services and maintenance activities, chemicals sector for providing insulation material, heating technology sector as well as electrical appliance (heat pumps) and related services and maintenance activities as well as the financing sector. Indirect effects are expected in sectors further up the value chain that provide materials, equipment, and services to the directly affected sectors. Furthermore, policy options/packages can impact the competitiveness of business by stimulating innovation, increasing market shares, or bringing down costs of inputs or technologies.

To assess impacts on demand, production, value added and employment in sectors immediately affected by the policy option plus sectors further up the value chain, both macro-economic modelling and a complementary bottom-up indicator-based assessment have been used.

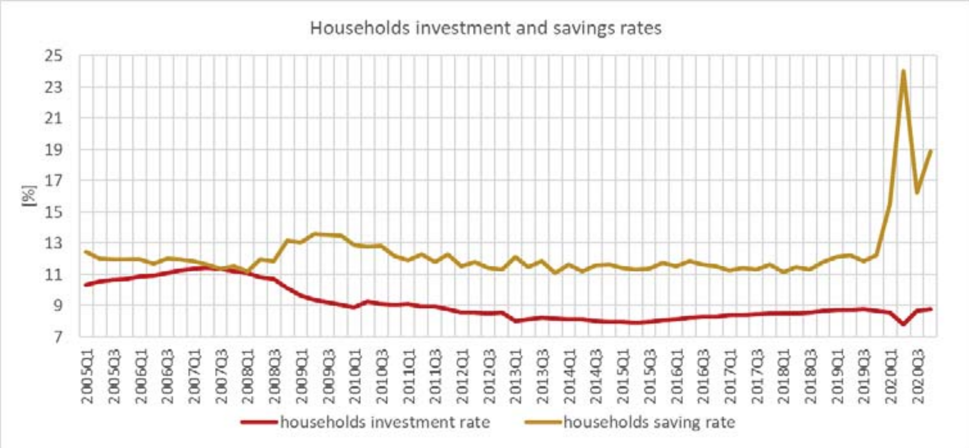
The EU construction sector is a major part of the EU economies that contributed with about 9% to the EU's GDP in 2019 and between 13 to 18 million direct jobs[43].

The COVID-19 crisis heavily impacted the EU economy with a loss in real GDP of about 6 to 7% in 2020, followed by a recovery process and projected increase of about 3.6 to 4.2% in 2021 and stable growth thereafter.[44] Consequently, the output in the buildings construction sector decreased in early 2020 and improved again in the fall of 2020, leaving a V-shape for the year 2020. This was a consequence of the measures limiting the economic activity and of households' tendency to save more and invest less during the crisis (see below figure). Impacts in the construction sector varied by country. Some countries, such as Denmark, Sweden, and Finland did not suffer output reductions in the industry, while other countries (e.g. Spain, France, Slovenia) were suffered more[45].

However, output in buildings constructions sector is projected to increase further with forecasted growth rates of 4.1% for 2021, 3.4% in 2022, and 2.4% in 2023[46].

Figure D.9: Evolution of buildings construction activity and households' investment/save rate 2005 - 2021[47]

43 European Commission, 2021, Construction Industry, available at: https://ec.europa.eu/growth/sectors/construction_en#:~:text=The%20construction%20industry%20is%20very,social%2C%20climate%20and%20energy%20challenges And Eurostat (nama_10_a64_e)
44 de Vet, J.M, et al. Impacts of the COVID-19 pandemic on EU industries, Publication for the committee on Industry, Research and Energy, Policy Department for Economic, Scientific and Quality of Life Policies, European Parliament, Luxembourg, 2021. https://www.europarl.europa.eu/RegData/etudes/STUD/2021/662903/IPOL_STU(2021)662903_EN.pdf
45 https://euroconstruct.org/ec/blog/2020_08
46 Idem.
47 Based on Eurostat data from [sts_copr_m] and [nasq_10_ki].



Source: Eurostat

Macro-economic modelling

The *macro-economic model* (EmIO-Europe - Employment Input-Output Model) is an input-output model for the EU based on the system of national accounts. It is set up to be used to analyse direct and indirect production, value added and employment effects of energy and climate policy measures in the EU. EmIO Europe uses a comparative static approach. It can give a basic assessment of the effect of the additional burden a policy or measure may impose on the economy as well of the effect of recycling of revenues that may be raised by a policy or measure. The financial burden to cover needed investments can be expressed as a reduction in demand distributed across sectors, while revenue recycling may – even at the same time – stimulate demand across the same or other sectors. The model can differentiate these demands induced third-stage effects for households, industry and/or government.

Model inputs to EmIO are provided by the BEAM² model and the micro-economic analysis. They include:

- Investment costs broken down by different types (equipment and installation) and sectors (e.g. construction sector, HVAC-systems, financing costs);
- Changes in EU final energy demand and costs for heating, hot water, cooling, auxiliary and lighting for the relevant time frame.

Model outputs will be compared to a baseline development and include effects on sectoral value added, production output, GDP, employment and consumer spending and trade.

As regards to economic effects outside the EU, to account for output, Value Added and employment effects induced in countries outside the EU, the multiregional Exiobase input-output model has also been used. The model relates the economic and final demand sectors of individual countries or world regions to each other and thus allows considering complex international supply chains. This helped identifying the economic effects of the policy options for countries outside the EU.

The breakdown of investment and demand impulses into economic sector aggregates reflects investment and reduction in energy expenditure derived from BEAM² modelling supplemented with information from the literature. The economic sector aggregates involve wood products for window frames and new build, chemical, rubber and plastic products for insulation material, glass and glass products for windows, metal products for heating technologies, heating pipes and new build, machinery and equipment for all purposes, electrical machinery and apparatus for heating technology, construction and reprocessing of construction materials for onsite construction and trade and services accompanying all activities, also including architects, real estate agents, retailers, logistics etc.

Social impacts

Distributional effects and in particular energy poverty is a key concern. In this respect, several indicators can contribute understanding the impacts of policies, including a broader context of energy poverty. A standard EU-definition of energy poverty is still missing. According to the Commission recommendation on energy poverty and in line with Regulation (EU) 2018/1999 and its recast 2019/944/EU, 'energy poverty' means a situation in which households cannot afford the essential energy services necessary for a decent standard of living. In line with the Annex[48] to the Energy Poverty Recommendation, the following indicators have been considered the most appropriate ones: energy expenditure of households in relation to an income measure, affordability (ability to keep home adequately warm in winter and cool in summer; arrears on utility bill (heating, electricity, gas), number of disconnections, share of population at risk of poverty below (60% of median equivalised income).

The assessment is based on the Eurostat EU-Statistics on Income and Living Conditions (EU-SILC), which is the EU reference source for comparative statistics on income distribution and social inclusion at the European level. In particular, the following data have been used:

- Data on income distribution on household level across MS and energy consumption
- Expenditures on electricity and heating purposes, additional expenditures and investments due to policy options
- Prices changes in consumer goods on different income groups and social status

[48] https://ec.europa.eu/energy/sites/ener/files/recommendation_on_energy_poverty_-_annex.pdf

EU-SILC data has been used for microsimulation-analysis to assess distributional impacts. The output of the analysis gives indications about how a price increase, or an induced change affects different household income groups. In particular, changes in expenditures (savings on energy and, if possible, also investment expenditure or rent increase) are shown in relation to disposable income. The representation across different income groups provides information on whether a policy option has a regressive or progressive effect, i.e. whether households with lower incomes are relatively more or less burdened than high-income households. The analysis thus provides indications for specific design features of the instruments which could become relevant also in the design of accompanying measures.

7. Assessment of impacts

7.1. Specific modelling choices

Some specific choices have been made in the modelling of MEPS, taking into account the constraints of the tools used:

- For MEPS1, in the residential sector the trigger of renovation to “class D” level has been applied primarily to Single Family Houses (SFH) and only marginally to small (SMFH) and large multi apartments’ ones (LMFH). This simplification has been applied to take into account that while the available data sources on sales and rentals reported transactions of single dwellings in SMFH and LMFH, in the modelling only the full buildings can be renovated. From the point of view of the assessment of effects. In addition, this conservative estimate would be more impactful in the countries and regions with higher shares of SMFH or LMFH. From a policy perspective this consideration relates to the need to factor in that specific measures at EU or national level need to be put in place to address the specificities of the renovation of multi-apartment residences.

- For MEPS2 and MEPS3, national MEPS schemes are modelled as standards that follow a progressive renovation pathway between 2025 and 2050 gradually and through a combination of staged and single deep renovations progressively achieve higher shares of buildings renovated to high standards, close to “ZEB levels”, thus achieving decarbonisation by 2050. The transformation modelled allows the achievement of a decarbonised building stock in the absence of other policies. This is a simplification of the diverse choices that national authorities could make in national MEPS alongside the trajectory and criteria established in the EPBD, and following which some buildings segments could be targeted with priority. Coherently with the baseline adopted for all “Fit for 55” proposals, this mechanism does not take into account the effect of other EU instruments which would affect building renovation, being regulatory ones (like the provisions in the EED related to the renovation of public buildings) or carbon pricing. From a modelling perspective this is a conservative approach based only on current policies, and it is likely to overestimate the renovation efforts which would need to be triggered by MEPS2 and MEPS3. From a policy perspective, this means that what is modelled is a "maximum effect" and in reality costs and investments for MEPS could be lower as some renovation efforts would be incentivised by other policy instruments which could be factored in in the specific design of national MEPS mechanisms. This reinforces the need for national mechanisms to introduce and enforce MEPS which should be adaptable and coherent with other policy drivers.

- For MEPS4 it has been modelled that the heating and cooling installations at end of life would be replaced by ones in higher Energy Label classes, avoiding the installations in the lowest class of the respective product category. It has been observed that within a certain period of application of this standard and following the rescaling of the Energy Label of the corresponding appliances, this would not allow anymore to purchase fossil based appliances in certain product categories.

7.2 Considerations regarding the impacts of MEPS at MSs level.

There are effects of the policy options that could vary across EU countries for multiple reasons, some of which are structural while others can be mitigated with proper policy design. The following circumstances play a role:

- The existing conditions and energy performance of the building stock;
- Climatic conditions;
- Calculation of energy classes in national EPCs schemes;
- Ownership structure and dynamics of the housing markets.

The first aspect reflects the starting point across countries and would imply that at parity of other conditions the countries which have already upgraded their building stock would find EU minimum standards (for instance under MEPS1) less stringent than others, and vice versa. However, these differentiations are expected to even out while the implementation of MEPS progress over time since in all countries the end-point would have to be the decarbonisation of the buildings stock for which MSs have already identified challenges and trajectories in their national LTRS. MEPS2 and MEPS3 can therefore be grounded in existing national strategies and offer a specific tool for their implementation. In addition, the harmonisation of EPC classes will contribute also to harmonize efforts on the compliance with minimum standards.

The thermal comfort and energy performances of buildings are closely connected, as a large amount of energy is used to control the indoor temperature of buildings and to make them thermally comfortable environments. The thermal comfort needs vary across countries and within them, depending on the climatic zones. This variability hasn't been a barrier to the development and implementation of effective policy tools in the EPBD and this is not expected to be an obstacle for effective application of minimum energy performance standards. With appropriate technical design, minimum standards for existing buildings and standards for new ones can ensure an adequate contribution to the goals of improving the energy performance and reducing greenhouse gas emissions across EU countries.

Energy performance certificates classify buildings according to their energy performance and they will be key tools to identify the buildings to be renovated and ensure compliance with MEPS, alongside with being essential information and awareness tools for building owners and tenants and other actors. 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. 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 for other assessment methods (i.e commercial rating systems) which have different coverage in different countries. The similarity between EPCs and the labelling of household appliances make it easy for citizens to access the information. The requirement that EPCs are present in advertisements for property transactions is also of big use for informing citizens. Furthermore, there are links between the EPCs and taxonomy and EPCs are to a large extent used in financial policies in MS. All this taken together means that EPCs is a powerful policy that can be made even stronger by improving coverage, quality, content and digital storage.

EPC classes across Europe currently do not correspond to comparable levels of energy performance, as national schemes have developed in parallel to cost-optimal calculations, largely reflecting national specificities and choices (see Annex G on EPCs).

This results in different levels of energy savings which are necessary to upgrade a building from the lowest class to higher classes. In particular, based on the current class distribution, on average the following reductions in energy performance are to be achieved:

- - 60% to upgrade buildings in the lowest class to Class C
- - 40% to upgrade buildings in the lowest class to Class D
- - 20% to upgrade buildings in the lowest class to Class E

Results also show significant variability across countries, with a range of savings to upgrade a building in the lowest class to class D in the vast majority of countries between 35% and 50%. This difference is due both to the specificities of the national class system, but also to climatic conditions and overall average performance of the building stock in the country, and the higher the savings to be achieved to ensure compliance with the standard set, the greater will normally be the costs of the renovation, at parity of other conditions.

This variability can be mitigated by ensuring comparable EPC classes across Europe and in particular with a system of classes in which the improvements needed to move upwards in classes is similar. This is one of the objectives pursued with options EPCQ1-EPCQ2-EPCQ3 which will strengthen quality alongside harmonisation of classes. The revision of EPCs will therefore contribute to a more even distribution of efforts in respecting minimum energy performance standards across EU countries.

The last aspect is also a structural one. Depending on a number of factors including economic conditions but also culture and habits, in some countries the number of transactions in the building markets in much higher and dynamic than in others. Similarly,, also the share of tenants in the all occupiers of buildings (residential or non residential) vary greatly. Split incentives present a substantial barrier to buildings refurbishment. Investment costs must be carried by landlords while tenants benefit from energy savings. Landlords lack incentives to undertake renovation efforts. This is most pronounced in countries with a high share of rental markets, and also more pronounced for low income households who more often live in rented properties.

The variable number of transaction will affect the efficiency of MEPS1, as in countries with more dynamic markets the triggers to apply MEPS1 will be greater, and therefore higher will be possibilities to improve the performance of buildings and to find a solution to split incentives. The application of MEPS1 in countries with fewer transactions will be on the contrary more modest. By combining MEPS1 with a national scheme and linking it to specific milestones and criteria (as in MEPS2) it is possible to counterbalance that effect. In countries in which transaction triggers will apply more often there will be less need to implement standards on the basis of national schemes, and vice versa.

Such differences also show the interest in combining different MEPS sub-options. In the Option 2 (Moderate scenario), while MEPS3 has effect only on non-residential buildings, MEPS1 triggers the renovation of worst performing buildings also in the residential market. Still given that MEPS1 applies to a fraction (progressively increasing over time) of residential buildings, a large share of residential stock is left unrenovated and it is not expected to be decarbonised by 2050 if only autonomous renovations will occur. Option 3 (HIGH-I scenario) has on the contrary the potential to gradually cover all the building stock in each MSs, with early effects on the properties being subject to transaction thus exploiting the benefits of renovating at existing “trigger points”, while other buildings will be renovated gradually on the basis of the national schemes put in place (MEPS2). Under Option 4 (HIGH-II) all the building stock will be covered by the different mechanisms put in place, with MEPS4 addressing specifically heating and cooling installations and ensuring that the worst performing ones are not installed once a replacement has to be made at end of life. The combination is expected to have the effect of accelerating the diffusion of highly efficient space and water heating appliances in comparison to Option 3, although with unclear effects as MEPS4 could lead to suboptimal choices if not accompanied by interventions on the buildings fabric and insulation.

7.3 Scenario description

Low Ambition / LOW (S1)

The LOW scenario is defined based on the BSL scenario. The central policy option is to improve the energy performance "worst performing" buildings, triggered by a sale or new rental contract from 2026 onwards, which is defined as minimum energy performance standard (MEPS1) achieving a performance equivalent to predefined EPC classes level. Based on EU-SILC data for sale of buildings and new rental contracts, the yearly rate of transaction is determined. This results in a conservative level of renovations. Non-residential buildings are also considered. Based on data from the project Hotmaps[49] and on further assumptions, the annual share of non-residential buildings affected by the trigger has been determined. For these residential and non-residential buildings an increased renovation rate has been applied in the modelling. The MEPS obligations are also reinforced with other policy elements such as building renovation passports (BRPs), EPCs, a deep renovation standard, long-term renovation strategies and the smart readiness indicator (SRI), which have from a modelling perspective an enabling and supportive character to the MEPS rather than a direct impact on model parameters. The heating system exchange mix is assumed the same way as in the BSL scenario.

Medium Ambition / MODERATE (S2)

In the medium ambition scenario S2 additional obligations are defined for non-residential buildings with floor area above 1,000 m² (MEPS3). Here it is assumed that these buildings have first obligations by 2026 and reach ZEB-level on average by 2045, accordingly the renovation rate is determined to reach significantly higher levels as in BSL. For all other buildings (residential and non-residential buildings below 1,000m²) the assumptions from the low ambition scenario S1 are applied. The MEPS obligations (same as in S1) are also aligned with the other policy elements such as building renovation passports (BRPs), EPCs, a deep renovation standard, long-term renovation strategies and the smart readiness indicator (SRI), which have from a modelling

[49] Hotmaps Project - The open source mapping and planning tool for heating and cooling (hotmaps-project.eu)

perspective an enabling and supportive character to the MEPS rather than a direct impact on model parameters.

The heating system exchange mix is assumed to be more in line with decarbonisation for the MEPS3 buildings (non-residential buildings larger than 1,000 m²), but is the same as in S1 for the other buildings (residential buildings and non-residential buildings smaller than 1,000m²).

High Ambition / HIGH-I (S3-I)

In the high-ambition scenarios all buildings are generally obliged to reach ZEB-level by certain years, except buildings for which exemptions/restrictions apply (included in the category "zeb-restricted"). In the S3-I scenario MEPS2 requires that all buildings are decarbonised progressively by 2050. Therefore, the respective building types and parts of the building stock are addressed by the modelling in such a way that as many buildings as possible can reach this target over time, but at the same time considering maximum feasible renovation activities in the building stock. Not only one-off renovations are assumed, but also set-by-step partial renovations that are target-compliant. The obligations that have been introduced in S2 for large non-residential buildings only are applied now for all buildings starting in 2026. The MEPS obligations (same as in S2 and S1) are also aligned with the other policy elements such as building renovation passports (BRPs), EPCs, a deep renovation standard, long-term renovation strategies and the smart readiness indicator (SRI), which have from a modelling perspective an enabling and supportive character to the MEPS rather than a direct impact on model parameters.

The heating system exchange mix is assumed to be more in line with decarbonisation for all buildings.

New buildings are assumed with a 100% ZEB-share from 2030 onwards.

High Ambition / HIGH-II (S3-II)

The second high ambition scenario S3-II is defined in the same way as S3-I and adds the obligation for all buildings to require best-in-class heating systems to be installed when replacements are made, starting in 2026 (MEPS4). The impact of this additional requirements is modelled with higher efficiency assumptions in the model for the new installed systems as well as a slightly more efficient heating system mix to be installed over time. The MEPS obligations (same as in S3-I, S2 and S1) are also aligned with a other policy elements such as building renovation passports (BRPs), EPCs, a deep renovation standard, long-term renovation strategies and the smart readiness indicator (SRI), which have from a modelling perspective an enabling and supportive character to the MEPS rather than a direct impact on model parameters.

New buildings are assumed with a 100% ZEB-share from 2030 onwards.

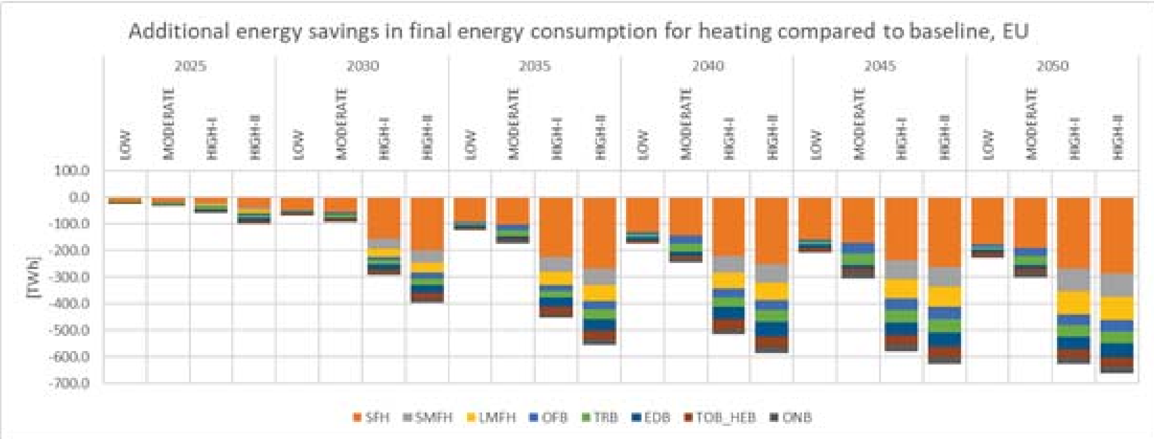
8. Modelling results

This section provides an overview of modelling results across scenarios, complementing the summary results provided in Chapter 6.

8.1 Energy and environmental impacts

Energy savings

Figure D.10: Additional energy savings in final energy consumption for space heating compared to baseline (at EU level)



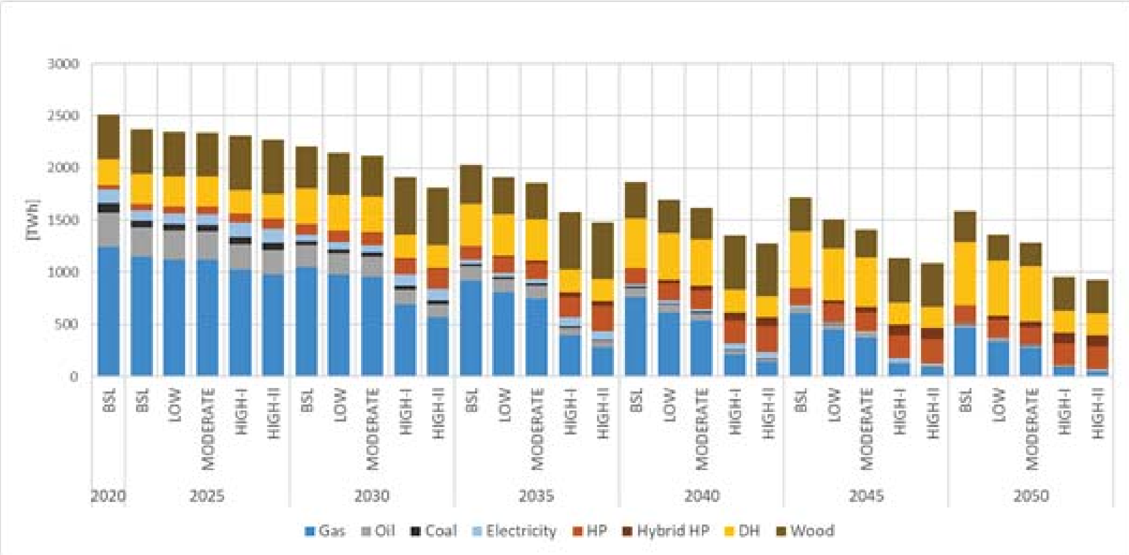
Source: Guidehouse et.al.

In all scenarios, the renovation of non-residential buildings generates about one third of the energy savings over the period 2030-2040.

As shown in Figure D.10, most energy savings until 2040 is achieved in single family houses (SFH)[50], which today represent around 46% in total stock and 63% in residential stock. This reflects the fact that worst performing buildings from residential sector, notably SFH, are the ones affected by MEPS1 across scenarios. The other building types are renovated relatively later, with the MODERATE scenario having effects on non-residential buildings, showing the effects of national schemes gradually requiring all buildings to be renovated at ZEB levels.

[50] The building types reported are the following: for residential buildings: Single Family House (SFH), Small Multi Family House (SMFH) and Large Multi Family House (LMFH). In the non-residential sector reference buildings have been developed along Annex I.5 of the EPBD: Office Building (OFB), Trade and Retail Building (TRB), Education Building (EDB), Touristic and Health Buildings (TOB_HEB), Other non-residential buildings (ONB). Note: Hospitals and hotels and restaurants are listed under Touristic/Health buildings (TOB_HEB). Sport facilities are addressed with other non-res buildings (ONB).

Figure D.11: Evolution of space heating energy consumption by sources at EU level



Source: Guidehouse et.al.

The renovations in the HIGH-II results also in significant impacts on the distribution of heating appliances (and consequently energy carriers) across the observed period in comparison to the baseline, towards decarbonisation by 2050. While in the baseline roughly 8 billion m^2 of floor area are still supplied by gas and oil in 2050, this share significantly decreases to less than 2 billion m^2 in HIGH-I and HIGH-II, with a quasi-complete phase-out of oil and coal. Compared to the baseline, there is a very significant increase in heat pumps that will supply an important part of the final energy consumption for heating in 2050[51]. By 2030, the relative importance of gas in buildings heating needs will decrease marginally in LOW and MODERATE scenarios (by about 4 %points) and by about 13 %points and 18 %points in HIGH-I and HIGH-II scenarios respectively. The decrease of relative importance of gas in buildings heating in HIGH-I is in line with the results from a recent JRC report[52].By 2050 and compared to 2030, the share of gas in the buildings' heating mix will further halve in the least ambitious scenarios whilst will be 4 and 6 times lower in the most ambitious ones. District heating share in heating mix of the buildings will increase in all scenarios but notably in LOW and MODERATE. Compared to baseline, wood fuels share in buildings heating mix will increase only by 1-2 %points in LOW and MODERATE scenarios and will grow more significantly in the two HIGH scenarios, reaching an almost double share by 2050.

[51] This includes hybrid heat pumps which are a combination of electric heat pumps and gas boilers, where the heat pump provides the base heat load during most of the heating season, while a gas boiler kicks in for peak loads. This leads to an assumed 70/30 distribution of heat supplied from the heat pump part vs. the gas boiler part of the hybrid system.
[52] Nijs W., Tarvydas D. and Toleikyte A., EU challenges of reducing fossil fuel use in buildings – The role of building insulation and low-carbon heating systems in 2030 and 2050, Publications Office of the European Union, Luxembourg, 2021, JRC127122.

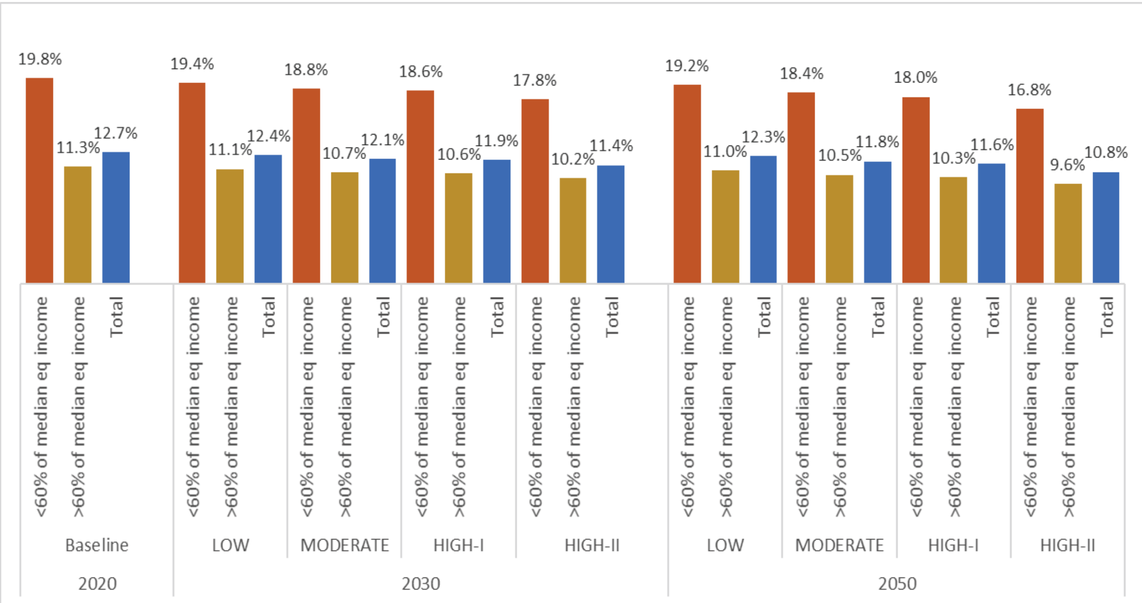
Air pollution, indoor environment, health and wellbeing

Air pollution

The impacts on air pollution are twofold. Renovation activities lead to an increase in pollutants in the construction industry while reduction of energy demand leads to a decrease in emissions, in particular in the gas and heat sector. In all four scenarios, the reduction effect offset the increase by 2050. Effects on pollutants are very small in LOW/MODERATE scenarios as renovation rates are rather low and subsequent energy reduction is moderate, while in HIGH-I and HIGH-II they are 2-3 times better [53].

The number of people affected by health issues due to inadequate renovation of their dwellings, especially by indoor cold and dampness will be reduced within the options identified for the revision of the EPBD, with different degrees of intensity and maximum effects achieved in the HIGH-I AND HIGH-II scenarios. Thanks to increased renovation rates and better insulated buildings as a result of the introduction of MEPS it is expected that rates of morbidity and mortality especially during winter will decrease, because of the decrease in the emergence of cardiovascular and respiratory diseases. This will reduce health care costs.

Figure D.12: Comparison across scenarios – share of total EU population living in a dwelling with a leaking roof, damp walls, floors or foundation, or rot in window frames or floor[54]

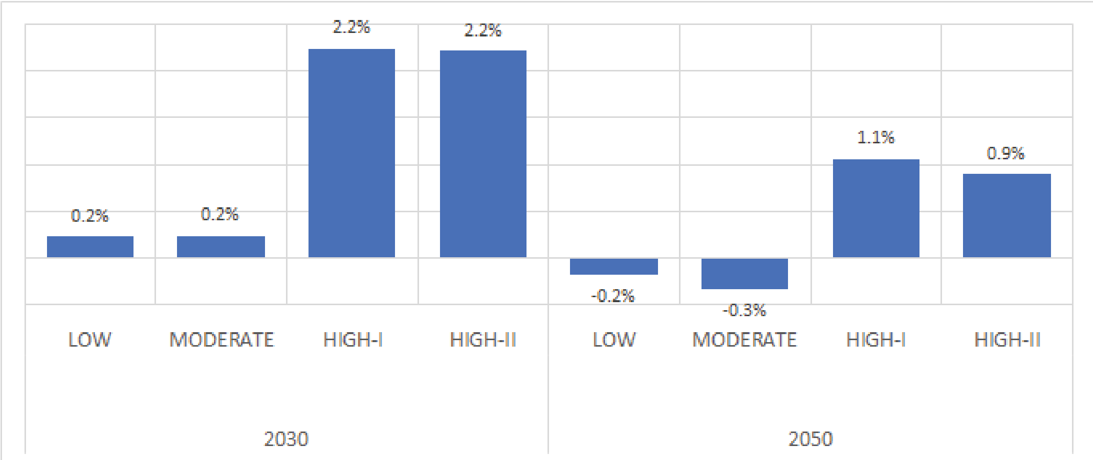


Source: Guidehouse (2021), based on Eurostat (ilc_mdho01)

[53] SO_x emissions decline slightly more than NO_x emissions because electricity and steam and hot water production are slightly more SO_x emissions intensive.
[54] Guidehouse (2021) based on Eurostat (ilc_mdho01)

Impacts on Material use

Figure D.13: Impact of renovation and new-build investment on material consumption within the EU (compared to 2020, total impact across all economic sectors)



Source: Guidehouse et.al.

The figure shows that investments in renovations and in highly efficient new constructions, translate into about 0.50.2% and 2.2% additional resource use in 2030 in LOW/MODERATE and HIGH-I AND HIGH-II scenarios compared to the of baseline. Resource use refers to the increase of those used in the construction and material sector and to the decrease in resources used within the gas and heat sector and also petroleum refining (included in industry) and fossil-based electricity (included in electricity). The increased materials are mainly coming from the EU, although around 30% of the construction materials are traded from Asia/Pacific. The quantitative impacts in 2050 are slightly higher but still account for about 0.5% of resource use recording a decrease of resource use in the least ambitious scenario (0.2%/0.3%) and to a smaller increase (0.9%-1.1%) in the most ambitious scenarios.

Market observers, industry analysts and construction trade associations have reported in 2021 unprecedented increases in prices and even supply shortages for certain construction materials. This effect has been linked to the disruption of supply chains of certain materials during the COVID-19 pandemic crisis and freight problems[55] that still persisted while the demand increased due to the recovery of the economy and the re-start of large-scale infrastructure construction activities in early 2021 (especially in China). The pandemic has in fact affected entire supply chains in unprecedented ways. Producers have been facing significant difficulties in sea and land transport. A shortage of

[55] The disruption of supply chains as a result of the COVID-19 pandemic has reduced container availability. This in turn has resulted in a significant increase in shipping prices. The March 2021 Suez crisis also had effects.

containers on the markets as a result of the broken trade routes have led to price increases. Factories had to be shut down or closed for maintenance and have not yet regained full capacity. The resulting increase in prices has been reported especially for timber, steel, cement and construction chemical products[56].

At the time of writing this Impact Assessment it is not possible to thoroughly evaluate the magnitude of the problem and to understand if it is a short-term temporary effect due to recovery and economic rebound while factories producing raw materials have still not reached full capacity, or if there are more structural causes behind the observed price increases. The current price hikes have to be monitored to understand if capacity adjustments will be put in place or if the markets are facing more structural imbalances. The increase in construction activities induced by the implementation across the EU of minimum buildings standard could also increase pressure on construction materials markets and supply chains starting from 2025-2026 or earlier due to market anticipation effects. Specific policy design for MEPS could also alleviate market pressure, for instance leaving adequate time to building owners to comply with the standards after the compliance date, as foreseen for MEPS1.

8.2 Economic impacts

Investments

Investments will have to be supported by building owners, being households, public authorities, companies or real estate sector, depending on the ownership structure of the specific country. Return on investments typically varies depending on how comprehensive the intervention is, with higher payback periods for the larger packages of renovations leading to deep renovations in which the building achieves very high efficiency standards. In the DEEP database[57], the average payback[58] period reported is 5 years[59]. This varies greatly across type of interventions (around 3 years for lighting and HVAC improvements to close to 11 years for building fabric improvements to a median

[56] Including paints and their components (such as epoxy resins – an important binder for many paints and coatings), polyurethane foams, sealants and construction adhesives (silicone, acrylic, hybrid and polyurethane).
[57] The Energy Efficiency Financial Institutions Group (EEFIG) was established in 2013 by the European Commission and the United Nations Environment Programme Finance Initiative (UNEP FI). EEFIG is composed of over 300 representatives from more than 200 organisations - spanning public and private financial institutions, industry representatives and sector experts and aims to accelerate private finance to energy efficiency. EEFIG aims to develop practical tools to facilitate the energy efficiency market. As one of these, EEFIG has developed the De-risking Energy Efficiency Platform (DEEP). The DEEP Database is intended to support financial institutions in energy efficiency investment decisions.
[58] Years required for the saving to pay for the investment without any interest costs.
[59] Overview data from 7767 energy efficiency projects in buildings. De-risking Energy Efficiency Platform -Factsheet (quick) (eefig.eu).

of 13,5 years for more integrated renovations)[60]. The highest returns are observed in the worst performing buildings. However, this value is based on a narrow approach, and on the assumption that such interventions will have to be repaid only by reduction over time in the energy bill. However, multiple economic and non-economic benefits are realised through investments in buildings renovations which are not taken into account in this simplified calculation.

Stakeholders have indicated that grants and subsidies schemes should be privileged over tax-refund incentives and loans[61], and that grants should target low-income households to facilitate social acceptance, enhance social inclusion[62] and increase the efficiency and overall societal benefits of MEPS.

One-stop-shops and technical assistance have also been considered crucial by stakeholders. One-stop-shops in combination with BRPs are key to help not only the demand side but also the supply side. BRPS will also help supply side because refurbishment packages can be standardised and lead to replicable business models. Stakeholders indicated also that channels for technical assistance and funds need to be better streamlined, it is currently too hard to navigate the EU funding mechanisms[63] as there is a wealth of information and a number of routes. Simplification, clarification and clearly earmarked funding are required.

Energy costs

In baseline scenario, energy costs for heating, cooling and DHW will increase by 17% in 2030 as compared to 2020. Thanks to energy savings achieved autonomously and driven by the policies in place in the baseline, the energy costs start decreasing from 2035 onwards going down to 2050 at just 2.3% higher than in 2020. This decrease will be

[60] See also the Impact Assessment Report Accompanying the proposal for a Directive of the European Parliament and of the Council amending Directive 2012/27/EU on energy efficiency.

[61] The International Union of Property Owners (UIPI) conducted a survey on European property owners' capacity and willingness to renovation (collecting 10.415 answers in 36 countries in Europe and published in March 2021). It shows that traditional forms of financial incentives seem to be the most effective ones. Subsidies and grants are the top choice incentives (54.03%) for homeowners and individual landlords that they would like to have set in place as a help to renovate followed by incentives related to tax reductions (36.95% (income tax credits/deductions – 40.61%, property tax deduction – 39.19%, VAT deduction – 31.06%). Other potential incentives that could enable homeowners to renovate are professional/technical advice (28.17%) and One-Stop-Shops (17.21%), while loans seem to be the least preferred incentive with a mean value of 8.17% (traditional loan and soft loan schemes –10.99%, loans with performance contract bill repayment model – 8.68%, loans with on-tax repayment model – 8.23%), UIPI – International Union of Property Owners – Union Internationale de la Propriete Immobiliere

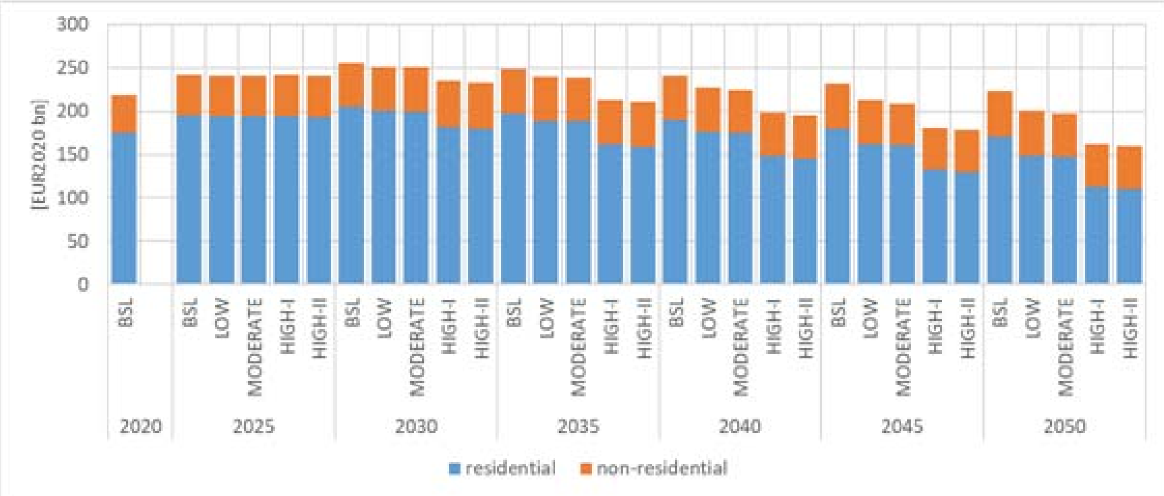
[62] This aspect is included in the recommendations by FEANTSA (2021), Renovation: Staying on Top of the Wave — Avoiding social risks and ensuring the benefits, European Federation of National Organisations Working with the Homeless. Renovation_Wave_final_report.pdf (feantsa.org)

[63] The SWD accompanying the Renovation Wave Communication provides an overview of funding available updated to September 2020; "Support from the EU budget to unlock investment into building renovation under the Renovation Wave", SWD(2020) 550 final.

driven by the reduction of energy use in the residential sector, although the energy costs in non-residential buildings will increase by about 18% and 24.5% in 2030 and 2050 respectively.

As result of more vigorous renovation measures, the energy costs evolution in the modelled scenarios increase less than in the baseline. In 2030 they increase by 15% in LOW/MODERATE scenarios and only by 6.6%/7.7% in HIGH-I/HIGH-II scenarios. By 2050, it is estimated that, compared to 2020 levels, the energy costs will go down by 8% / 10% in LOW / MODERATE scenarios and by about 26% in the two HIGH scenarios. Still by 2050 and compared to 2020 levels, thanks to the reduction of the energy demand through renovation, the energy costs in residential buildings will go down by 15% / 16% in LOW/MODERATE scenarios and by about 36%/37% in HIGH-I/HIGH-II scenarios. For non-residential buildings the energy costs by 2050 will still increase compared to 2020 levels, but only by 17% in MODERATE scenario and by around 15% in the two HIGH scenarios.

Figure D.14: Evolution of the energy costs for heating, cooling and domestic hot water at EU level



Source: Guidehouse et.al.

8.3 Social impacts

It is expected that the effects in costs reductions will be more pronounced in low-income groups as worst performing buildings are occupied in relative higher shares by low-income households[64]. The quantitative effect is however difficult to assess because the share of low-income population living in worst performing buildings is not known. If assumed that renovations and subsequent energy savings are distributed proportionally to

[64] Mellwig, P. et al. (2021): Gebäude mit der schlechtesten Leistung (Worst performing Buildings) - Klimaschutzpotenzial der unsanierten Gebäudein Deutschland. Download: https://www.gruene-bundestag.de/fileadmin/media/gruenebundestag_de/themen_az/bauen/PDF/210505-ifeu-kurzstudie-gebaeude-mit-schlechtester-leistung.pdf

expenditure shares, in the two HIGH scenarios, the lowest-income households in the first quintile will save in 2030 around 100 PPP per year compared to 2020. In 2030 in the same HIGH scenarios, higher-income households in the fifth quintile save around 200-230 PPP through energy efficiency measures in buildings. In 2030, the savings in heat and electricity expenditure in LOW/MODERATE scenarios will be significantly lower, i.e. at around 17-19 PPP for the lowest-income quintile and 37-42 PPP for the highest-income quintile.

As regards MEPS1, by addressing the renovation of worst performing buildings, this measure is also expected to have higher impacts on lower-income quintiles, in which the share of tenants (facing split incentives) is statistically greatest.

Figure D.15 Evolution of heat and electricity expenditure by income quintiles at EU level (compared to baseline)[65]

Source: Guidehouse et al.

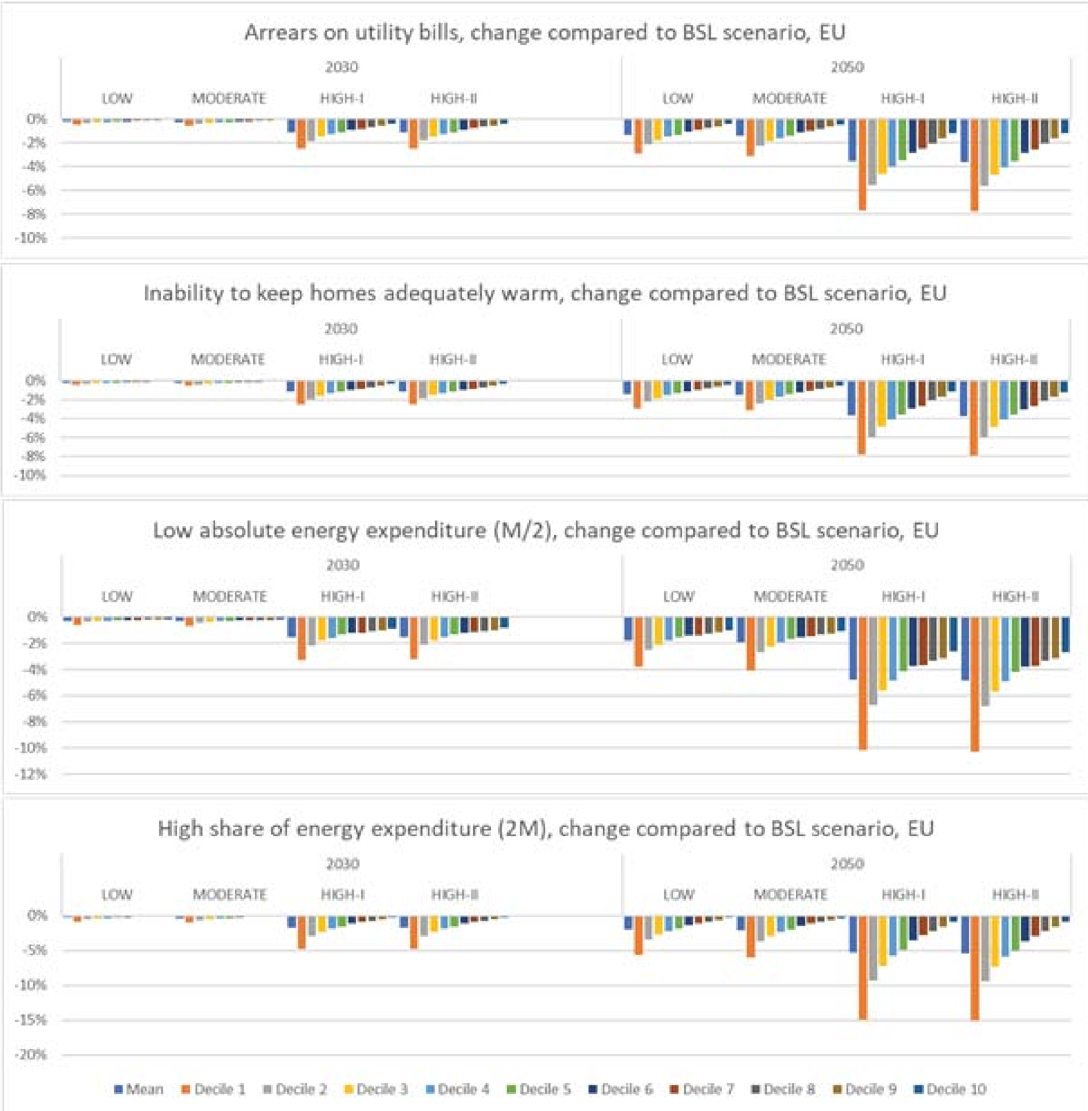
Respiratory infectious diseases that occur due to indoor air tightness can be avoided by insulation and adequate ventilation systems. Thermal insulation and an upgrade of the heating or ventilation system can prevent indoor cold and dampness, avoid unhealthy conditions and decrease the cases of cold and asthma related morbidity and mortality significantly. However, better insulation can possibly also have negative health impacts, because of reduced air flow, if no adequate ventilation system is installed.

Worst-performing buildings are a burden on their occupants: because of the high heating costs, they are usually not adequately heated. Comfort is correspondingly low. In inadequately heated buildings, damp and mold can lead to health problems[66]. It is

[65] Guidehouse *et al.* (2021) based on Eurostat (hbs_str_t223).
[66] BPIE (2019) estimates, that about 2.2 million Europeans have asthma because of their living conditions and 110 million live in buildings with high concentrations of hazardous pollutants due to inadequate levels of ventilation. It will be expected that rates of morbidity and mortality especially during winter will

estimated that about 2.2 million Europeans have asthma because of their living conditions and 110 million live in buildings with high concentrations of hazardous pollutants due to inadequate levels of ventilation.

Figure D.16: Change in share of main energy poverty indicators in the EU population per income decile compared to the baseline scenario[67]



Source: Guidehouse et.al.

8.3.1. Results of sensitivity analysis for distributional impact and financial support for low-income households undertaking renovation

---

decrease, because of the less emergence of cardiovascular and respiratory diseases. This will reduce health care costs. http://bpie.eu/wp-content/uploads/2019/04/Policy-paper_IEQ-_Final.pdf

[67] Guidehouse based on the EU Energy Poverty Observatory and Eurostat (EU SILC; Household Budget Survey)

Table D.17: Impact of ZEB renovation on a low-income household living in a rented apartment from a multi-family house

Multi-familiy house (MFH) unit, average floor area of 75m2, inhabited by a tenant, initial status: not renovated, undertake ZEB renovation											
		Share of tenants (%)		Annual household Income		affected low income households (< 60% median, i.e. 30% of all households)	Investment per MFH unit	Energy savings			
EU Region	Member State with the highest share of tenants per region	< 60% median income	> 60% median income	1. Quintile (low income)	4. Quintile (high income)			annual	(present value)*	*low income household*	*high income household*
		%	*%*	*Euro*	*Euro*	*number*	*Euro*	*Euro*	*Euro*	*(% of income)*	*(% of income)*
NO	DK	69.3	34.9	21,388 €	43,206 €	603,542	19,654 €	938 €	12,917 €	4.4%	2.2%
WE	DE	74.9	44.3	15,612 €	33,976 €	9,327,209	18,718 €	1,216 €	16,735 €	7.8%	3.6%
SO	CY	60.4	27.3	10,532 €	23,890 €	58,783	9,160 €	543 €	7,478 €	5.2%	2.3%
NE	CZ	43.4	18.9	7,204 €	14,153 €	42,238	7,476 €	566 €	7,788 €	7.9%	4.0%
SE	SK	20.9	7.5	5,740 €	11,142 €	117,842	5,706 €	412 €	5,672 €	7.2%	3.7%

*annualised costs over 30 years period and with 6% discount rate

EU Region	Scenario 1 - full cost pass through, no investment support			Scenario 2, limited pass through to tenants (75%)			Scenario 3, limited passed through to tenants (40%)			Scenario 1 - full pass through	Scenario 2 - 75% pass through	Scenario 3 - 40% pass through
	increase in rent due to	Possible rent increase (% of income)		increase in rent due to	Possible rent increase (% of income)		increase due to	Possible rent increase (% of income)		Net Effect - Rent increase minus energy savings (% of income)		
	Euro	*low income HH*	*high income HH*	*Euro*	*low income HH*	*high income HH*	*Euro*	*low income HH*	*high income HH*	*low income HH*	*low income HH*	*low income HH*
NO	1,428 €	6.7%	3.3%	1,071 €	5.0%	2.5%	571 €	2.7%	1.3%	2.3%	0.6%	-1.7%
WE	1,360 €	8.7%	4.0%	1,020 €	6.5%	3.0%	544 €	3.5%	1.6%	0.9%	-1.3%	-4.3%
SO	665 €	6.3%	2.8%	499 €	4.7%	2.1%	266 €	2.5%	1.1%	1.2%	-0.4%	-2.6%
NE	543 €	7.5%	3.8%	407 €	5.7%	2.9%	217 €	3.0%	1.5%	-0.3%	-2.2%	-4.8%
SE	415 €	7.2%	3.7%	311 €	5.4%	2.8%	166 €	2.9%	1.5%	0.1%	-1.8%	-4.3%

Source: Guidehouse et.al.

Table D.18: Impact of partial ZEB renovation on a low-income household living in a rented apartment from a multi-family house

Multi-familiy house (MFH) unit, average floor area of 75m2, inhabited by a tenant, initial status: not renovated, undertake partial ZEB renovation											
		Share of tenants (%)		Annual household Income		affected low income households (< 60% median, i.e. 30% of all households)	Investment per MFH unit	Energy savings			
EU Region	Member State with the highest share of tenants per region	< 60% median income	> 60% median income	1. Quintile (low income)	4. Quintile (high income)			annual	(present value)*	*low income household*	*high income household*
		%	*%*	*Euro*	*Euro*	*number*	*Euro*	*Euro*	*Euro*	*(% of income)*	*(% of income)*
NO	DK	69.3	34.9	21,388 €	43,206 €	603,542	4,323 €	51 €	707 €	0.2%	0.1%
WE	DE	74.9	44.3	15,612 €	33,976 €	9,327,209	4,045 €	111 €	1,531 €	0.7%	0.3%
SO	CY	60.4	27.3	10,532 €	23,890 €	58,783	909 €	20 €	271 €	0.2%	0.1%
NE	CZ	43.4	18.9	7,204 €	14,153 €	42,238	759 €	35 €	480 €	0.5%	0.2%
SE	SK	20.9	7.5	5,740 €	11,142 €	117,842	785 €	41 €	570 €	0.7%	0.4%

*annualised costs over 30 years period and with 6% discount rate

EU Region	Scenario 1 - full cost pass through, no investment support			Scenario 2, limited pass through to tenants (75%)			Scenario 3, limited passed through to tenants (40%)			Scenario 1 - full pass through	Scenario 2 - 75% pass through	Scenario 3 - 40% pass through
	increase in rent due to	Possible rent increase (% of income)		increase in rent due to	Possible rent increase (% of income)		increase due to	Possible rent increase (% of income)		Net Effect - Rent increase minus energy savings (% of income)		
	Euro	*low income HH*	*high income HH*	*Euro*	*low income HH*	*high income HH*	*Euro*	*low income HH*	*high income HH*	*low income HH*	*low income HH*	*low income HH*
NO	314 €	1.5%	0.7%	236 €	1.1%	0.5%	126 €	0.6%	0.3%	1.2%	0.9%	0.3%
WE	294 €	1.9%	0.9%	220 €	1.4%	0.6%	118 €	0.8%	0.3%	1.2%	0.7%	0.0%
SO	66 €	0.6%	0.3%	50 €	0.5%	0.2%	26 €	0.3%	0.1%	0.4%	0.3%	0.1%
NE	55 €	0.8%	0.4%	41 €	0.6%	0.3%	22 €	0.3%	0.2%	0.3%	0.1%	-0.2%
SE	57 €	1.0%	0.5%	43 €	0.7%	0.4%	23 €	0.4%	0.2%	0.3%	0.0%	-0.3%

Source: Guidehouse et.al.

Table D.19: Impact of ZEB renovation on a low-income household living in the owned single-family house

Single-familiy house (SFH), average floor area of 130m2, inhabited by the owner, initial status: not renovated, undertake ZEB renovation

MS-Region	MS (highest share of owners per region)	Share of owners (%) < 60% median income	Share of owners (%) > 60% median income	Annual household Income 1. Quintile (low income)	Annual household Income 4. Quintile (high income)	affected low income households (< 60% median, i.e. 30% of all households)	Investment per SFH	Energy savings annual	Energy savings (present value)*	Energy savings low income household	Energy savings high income household
		%	%	Euro	Euro	number	Euro	Euro	Euro	(% of income)	(% of income)
NO	FI	44.4	74.6	17,183 €	35,520 €	367,493	56,587 €	2,722 €	37,462 €	15.8%	7.7%
WE	BE	37.4	77.2	16,141 €	33,773 €	558,830	39,889 €	2,623 €	36,101 €	16.2%	7.8%
SO	ES	55.3	81.6	8,847 €	24,104 €	3,114,743	22,675 €	1,441 €	19,834 €	16.3%	6.0%
NE	SI	44.4	22.5	9,939 €	19,321 €	115,490	34,533 €	2,643 €	36,385 €	26.6%	13.7%
SE	SK	20.9	7.5	5,740 €	11,142 €	117,842	26,051 €	2,294 €	5,672 €	40.0%	20.6%

annualised costs over 30 years period and with 6% discount rate

EU Region	Scenario 1 - full cost pass through, no investment support: Investment cost*	Scenario 1: Possible increase of housing cost (% of income) low income HH	Scenario 1: Possible increase of housing cost (% of income) high income HH	Scenario 2, investment grant (25%): Investment cost (net of subsidy)	Scenario 2: Possible increase of housing cost (% of income) low income HH	Scenario 2: Possible increase of housing cost (% of income) high income HH	Scenario 3, investment grant (60%): Investment cost (net of subsidy)	Scenario 3: Possible increase of housing cost (% of income) low income HH	Scenario 3: Possible increase of housing cost (% of income) high income HH	Net Effect - Housing cost increase minus energy savings (% of income): Scenario 1 - no invest. support, low income HH	Net Effect: Scenario 2 - 25% invest support, low income HH	Net Effect: Scenario 3 - 60% invest support, low income HH
	Euro			Euro			Euro					
NO	4,111 €	23.9%	11.6%	3,083 €	17.9%	8.7%	1,644 €	9.6%	4.6%	8.1%	2.1%	-6.3%
WE	2,898 €	18.0%	8.6%	2,173 €	13.5%	6.4%	1,159 €	7.2%	3.4%	1.7%	-2.8%	-9.1%
SO	1,647 €	18.6%	6.8%	1,235 €	14.0%	5.1%	659 €	7.4%	2.7%	2.3%	-2.3%	-8.8%
NE	2,509 €	25.2%	13.0%	1,882 €	18.9%	9.7%	1,004 €	10.1%	5.2%	-1.4%	-7.7%	-16.5%
SE	1,893 €	33.0%	17.0%	1,420 €	24.7%	12.7%	757 €	13.2%	6.8%	-7.0%	-15.2%	-26.8%

Source: Guidehouse et.al.

Table D.20: Impact of partial ZEB renovation on a low-income household living in the owned single-family house

Single-familiy house (SFH), average floor area of 130m2, inhabited by the owner, initial status: not renovated, undertake partial ZEB renovation

MS-Region	MS (highest share of owners per region)	Share of owners (%) < 60% median income	Share of owners (%) > 60% median income	Annual household Income 1. Quintile (low income)	Annual household Income 4. Quintile (high income)	affected low income households (< 60% median, i.e. 30% of all households)	Investment per SFH	Energy savings annual	Energy savings (present value)*	Energy savings low income household	Energy savings high income household
		%	%	Euro	Euro	number	Euro	Euro	Euro	(% of income)	(% of income)
NO	FI	44.4	74.6	17,183 €	35,520 €	367,493	20,057 €	326 €	4,490 €	1.9%	0.9%
WE	BE	37.4	77.2	16,141 €	33,773 €	558,830	10,561 €	505 €	6,945 €	3.1%	1.5%
SO	ES	55.3	81.6	8,847 €	24,104 €	3,114,743	4,467 €	116 €	1,603 €	1.3%	0.5%
NE	SI	44.4	22.5	9,939 €	19,321 €	115,490	11,179 €	350 €	4,814 €	3.5%	1.8%
SE	SK	20.9	7.5	5,740 €	11,142 €	117,842	7,968 €	489 €	6,731 €	8.5%	4.4%

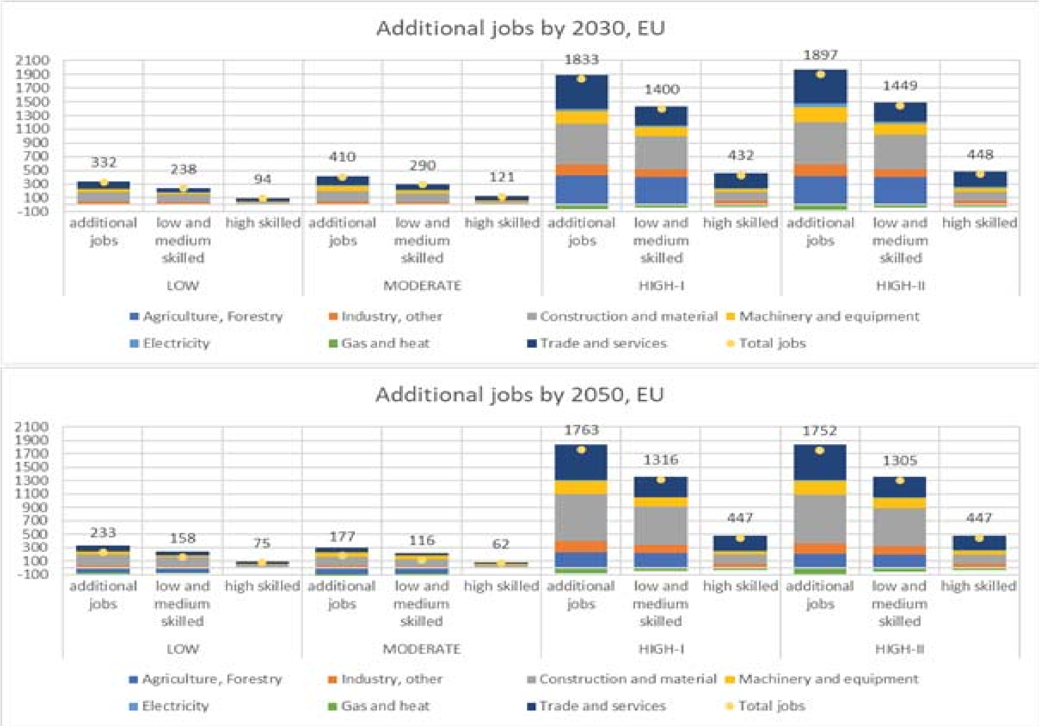
annualised costs over 30 years period and with 6% discount rate

EU Region	Scenario 1 - full cost pass through, no investment support: Investment cost*	Scenario 1: Possible increase of housing cost (% of income) low income HH	Scenario 1: Possible increase of housing cost (% of income) high income HH	Scenario 2, investment grant (25%): Investment cost (net of subsidy)	Scenario 2: Possible increase of housing cost (% of income) low income HH	Scenario 2: Possible increase of housing cost (% of income) high income HH	Scenario 3, investment grant (60%): Investment cost (net of subsidy)	Scenario 3: Possible increase of housing cost (% of income) low income HH	Scenario 3: Possible increase of housing cost (% of income) high income HH	Net Effect - Housing cost increase minus energy savings (% of income): Scenario 1 - no invest. support, low income HH	Net Effect: Scenario 2 - 25% invest support, low income HH	Net Effect: Scenario 3 - 60% invest support, low income HH
	Euro			Euro			Euro					
NO	1,457 €	8.5%	4.1%	1,093 €	6.4%	3.1%	583 €	3.4%	1.6%	6.6%	4.5%	1.5%
WE	767 €	4.8%	2.3%	575 €	3.6%	1.7%	307 €	1.9%	0.9%	1.6%	0.4%	-1.2%
SO	325 €	3.7%	1.3%	243 €	2.8%	1.0%	130 €	1.5%	0.5%	2.4%	1.4%	0.2%
NE	812 €	8.2%	4.2%	609 €	6.1%	3.2%	325 €	3.3%	1.7%	4.7%	2.6%	-0.3%
SE	579 €	10.1%	5.2%	434 €	7.6%	3.9%	232 €	4.0%	2.1%	1.6%	-1.0%	-4.5%

Source: Guidehouse et.al.

Employment

Figure D.21: Impact of renovation and new-build investment AND reduced energy consumption on low and medium skilled employment, 2030 – all building types[68]



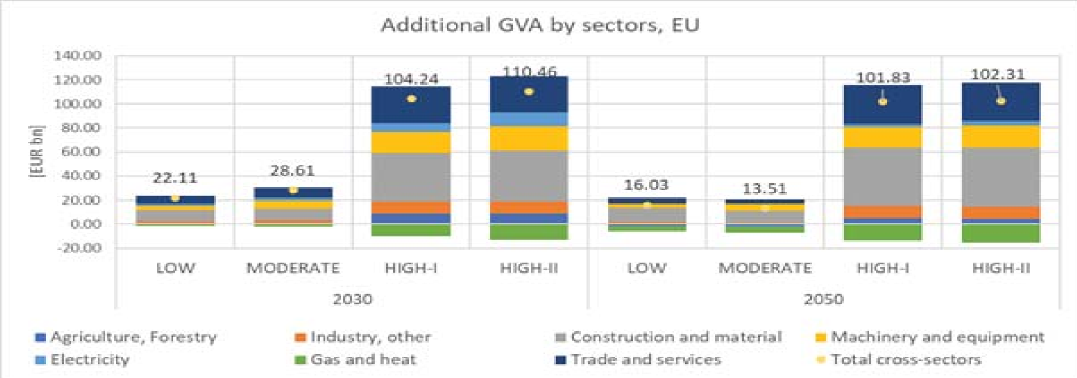
Source: Guidehouse et.al.

<u>Value added</u>

Figure D.22: Impact of renovation and new-build investment and reduced energy consumption on value added at the EU level[69]

---

[68] Exiobase modelling, <u>absolute values estimated based on changes of domestic consumption induced by the investment impulse in the affected sectors (conservative approach)</u>



Source: Guidehouse et.al.

A summary of main modelling results for the preferred option are presented in the tables below.

[69] Exiobase modelling, absolute values estimated based on changes of domestic consumption induced by the investment impulse in the affected sectors (conservative approach)

Table D.23: Summary of main results for the preferred option HIGH-I (source: Guidehouse et.al.)

HIGH-I scenario: Main results	[unit]	2030	2040	2050
GHG emission* savings in heating/cooling/DHW	[% from BSL]	-22.8%	-49.7%	-53.5%
heating	[% from BSL]	-24.9%	-53.3%	-58.8%
residential	[% from BSL]	-28.9%	-55.3%	-61.5%
non-residential	[% from BSL]	-10.4%	-38.7%	-40.0%
Energy savings in heating/cooling/DHW	[% from BSL]	-11.7%	-24.4%	-33.9%
heating	[% from BSL]	-13.3%	-27.6%	-39.5%
residential	[% from BSL]	-13.0%	-24.8%	-38.2%
non-residential	[% from BSL]	-8.8%	-23.6%	-26.7%
Additional investment	[% from BSL]	80.3%	90.9%	75.2%
renovation of existing buildings	[% from BSL]	113.9%	127.4%	104.8%
new buildings	[% from BSL]	8.6%	12.9%	11.9%
Energy costs savings for heating, cooling and DHW	[% from BSL]	-7.9%	-18.0%	-27.6%
residential	[% from BSL]	-11.0%	-21.8%	-33.8%
non-residential	[% from BSL]	4.5%	-3.8%	-7.9%
Evolution of the renovated floor area				
Renovated floor area post-2020 (cumulative)	[% of total floor area]	23.0%	55.0%	66.0%
Average share of deeply renovated in total renovated floor area after 2020 (over 5 yrs)	[% of total renovated area]	3.9%	39.6%	59.2%
Average renovation rate in full renovation equivalent (over 5 yrs)	[% of total floor area]	3.0%	3.3%	2.3%
Macro-economic impact				
Additional low and medium skilled jobs	[% from 2020]	1.24%		1.18%
Additional high skilled jobs	[% from 2020]	0.63%		0.65%
Additional value-added created in the EU	[% from 2020]	0.86%		0.85%
Environmental impact				
Air pollution				
Sox	[% from 2020]	-1.2%		-5.9%
Nox	[% from 2020]	0.3%		-1.0%
PM 2.5 and 10	[% from 2020]	0.1%		-0.8%
Water use	[% from 2020]	0.4%		0.3%
Material use	[% from 2020]	2.2%		1.1%
Social impact				
Household expenditure				
Share of heating expenditure in total expenditure				
Quintile 1	[% from 2020]	-0.4%		-1.3%
Quintile 2	[% from 2020]	-0.4%		-1.2%
Quintile 3	[% from 2020]	-0.4%		-1.1%
Quintile 4	[% from 2020]	-0.3%		-1.0%
Quintile 5	[% from 2020]	-0.3%		-0.8%
Share of electricity expenditure in total expenditure				
Quintile 1	[% from 2020]	-0.4%		-1.2%
Quintile 2	[% from 2020]	-0.4%		-1.1%
Quintile 3	[% from 2020]	-0.3%		-1.0%
Quintile 4	[% from 2020]	-0.3%		-0.9%
Quintile 5	[% from 2020]	-0.2%		-0.8%
Energy poverty indicators (mean change across deciles)				
Arrears on utility bills	[%points from BSL]	-1.2%		-3.6%
Inability to keep home adequately warm	[%points from BSL]	-1.2%		-3.7%
Low absolute energy expenditure (M/2)	[%points from BSL]	-1.6%		-4.8%
High share of energy expenditure in income (2M)	[%points from BSL]	-1.7%		-5.3%
Population in a dwelling with a leaking roof, damp, rot frames				
<60% of median eq income	[% from 2020]	-1.2%		-1.8%
>60% of median eq income	[% from 2020]	-0.7%		-1.0%
Total population	[% from 2020]	-0.8%		-1.1%

** direct emission from buildings and indirect from power&heat sector*

Table D.24: Summary of key scenarios results (source: Guidehouse et al.)

Baseline scenario - BSL							1
	2020	2025	2030	2035	2040	2045	2050
Building stock							
by type of building [bn m2]							
Single family house	*11.1*	*11.4*	*11.8*	*12.2*	*12.6*	*13.0*	*13.5*
Small multifamily house	*2.9*	*3.0*	*3.1*	*3.2*	*3.3*	*3.4*	*3.5*
Large multifamily house	*3.8*	*3.9*	*4.1*	*4.2*	*4.3*	*4.5*	*4.6*
office buildings	*1.5*	*1.6*	*1.7*	*1.7*	*1.8*	*1.9*	*2.0*
trade and retail buildings	*1.5*	*1.6*	*1.6*	*1.7*	*1.8*	*1.9*	*2.0*
educational buildings	*1.1*	*1.2*	*1.2*	*1.3*	*1.4*	*1.4*	*1.5*
tourism and heath building	*1.3*	*1.4*	*1.4*	*1.5*	*1.6*	*1.6*	*1.7*
other buildings	*0.9*	*0.9*	*1.0*	*1.0*	*1.1*	*1.2*	*1.2*
total residential	*17.8*	*18.4*	*19.0*	*19.6*	*20.2*	*20.9*	*21.5*
total non-residential	*6.3*	*6.6*	*7.0*	*7.3*	*7.7*	*8.1*	*8.5*
total residential and non-residential	24.1	25.0	25.9	26.9	27.9	29.0	30.1
by type of measure [bn m2]							
not renovated	*13.3*	*12.2*	*11.0*	*9.7*	*8.4*	*6.9*	*5.4*
already renovated	*10.3*	*9.5*	*8.4*	*7.2*	*6.0*	*4.9*	*3.7*
renovation - average	*0.3*	*2.1*	*4.2*	*6.4*	*8.7*	*11.0*	*13.4*
renovation - ZEB partial-not renovated	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
renovation - ZEB partial-already renovated	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
renovation - ZEB restricted	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
renovation - ZEB	*0.0*	*0.0*	*0.1*	*0.1*	*0.2*	*0.3*	*0.4*
total existing buildings	*23.9*	*23.8*	*23.6*	*23.4*	*23.3*	*23.1*	*22.9*
new building - nZEB standard (nearly-zero energy)	*0.2*	*1.2*	*2.1*	*3.1*	*4.0*	*4.9*	*5.8*
new building - ZEB standard (zero emission)	*0.0*	*0.1*	*0.2*	*0.4*	*0.6*	*1.0*	*1.4*
total new buildings	*0.2*	*1.2*	*2.3*	*3.4*	*4.6*	*5.9*	*7.2*
Average renovation rate in full renovation equivalent							
(over 5 yrs) [%total floor area]	*1.35%*	*1.47%*	*1.7%*	*1.7%*	*1.7%*	*1.7%*	*1.7%*
Average share of deeply renovated after 2020							
(over 5 yrs) [% of total renovated area]	*1.00%*	*1.22%*	*1.4%*	*1.7%*	*2.0%*	*2.2%*	*2.6%*
Environmental impact							
heating, by type of building [Mt CO2 eq]							
Single family house	*222.8*	*197.5*	*170.7*	*144.0*	*110.5*	*86.3*	*69.6*
Small multifamily house	*44.6*	*39.3*	*33.7*	*28.2*	*21.6*	*16.7*	*13.2*
Large multifamily house	*45.7*	*39.9*	*34.0*	*28.2*	*21.1*	*16.2*	*12.8*
office buildings	*31.3*	*28.4*	*25.1*	*21.9*	*17.6*	*14.8*	*13.1*
trade and retail buildings	*36.7*	*32.9*	*28.9*	*25.0*	*19.9*	*16.5*	*14.5*
educational buildings	*35.4*	*32.4*	*29.0*	*25.8*	*21.1*	*18.1*	*16.5*
tourism and heath building	*22.9*	*20.5*	*17.9*	*15.4*	*12.2*	*10.0*	*8.6*
other buildings	*21.8*	*19.6*	*17.2*	*14.9*	*11.9*	*9.9*	*8.7*
total residential	*313.1*	*276.7*	*238.4*	*200.4*	*153.2*	*119.1*	*95.6*
total non-residential	*148.1*	*133.6*	*118.1*	*103.0*	*82.7*	*69.4*	*61.4*
total residential and non-residential	*461.1*	*410.3*	*356.5*	*303.4*	*235.9*	*188.5*	*157.1*
heating, by type of measure [Mt CO2 eq]							
not renovated	*312.5*	*264.8*	*217.5*	*171.9*	*120.5*	*82.7*	*55.1*
already renovated	*144.4*	*120.0*	*93.6*	*69.2*	*45.3*	*28.9*	*17.4*
renovation - average	*3.2*	*18.9*	*33.9*	*46.4*	*51.7*	*55.0*	*58.6*
renovation - ZEB partial-not renovated	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
renovation - ZEB partial-already renovated	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
renovation - ZEB restricted	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
renovation - ZEB	*0.0*	*0.1*	*0.3*	*0.4*	*0.6*	*0.7*	*0.9*
total existing buildings	*460.0*	*403.9*	*345.3*	*287.9*	*218.0*	*167.4*	*132.0*
new building - nZEB standard (nearly-zero energy)	*1.1*	*6.2*	*10.5*	*14.2*	*16.0*	*18.4*	*21.3*
new building - ZEB standard (zero emission)	*0.0*	*0.3*	*0.7*	*1.3*	*1.9*	*2.7*	*3.8*
total new buildings	*1.1*	*6.5*	*11.2*	*15.6*	*17.9*	*21.1*	*25.1*
heating, by type of fuel [Mt CO2 eq]							
Coal	*32.9*	*21.1*	*12.6*	*6.9*	*3.6*	*1.7*	*0.7*
Oil	*86.2*	*75.8*	*55.8*	*36.8*	*23.9*	*15.1*	*9.1*
Gas	*251.7*	*231.9*	*212.2*	*186.0*	*153.7*	*121.9*	*94.3*
District heating	*52.1*	*50.1*	*48.6*	*49.5*	*37.7*	*35.5*	*39.2*
Electricity	*30.8*	*19.7*	*11.3*	*6.1*	*2.6*	*1.3*	*0.8*
Solid biomass	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Heat pumps	*7.4*	*11.7*	*16.0*	*18.1*	*14.4*	*13.0*	*13.0*
Hybrid heat pumps	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
total impact envelope + equipment [Mt CO2 eq]							
residential total	*373.3*	*332.0*	*288.0*	*245.3*	*189.3*	*150.3*	*124.9*
heating	*313.1*	*276.7*	*238.4*	*200.4*	*153.2*	*119.1*	*95.6*
domestic hot water	*50.3*	*46.2*	*42.6*	*38.9*	*32.1*	*28.1*	*26.3*
cooling	*10.0*	*9.0*	*7.0*	*6.0*	*4.0*	*3.0*	*3.0*
non-residential total	*179.7*	*161.4*	*142.0*	*123.2*	*98.1*	*82.4*	*74.2*
heating	*148.1*	*133.6*	*118.1*	*103.0*	*82.7*	*69.4*	*61.4*
domestic hot water	*17.6*	*15.7*	*13.9*	*12.2*	*9.4*	*8.1*	*7.8*
cooling	*14.0*	*12.0*	*10.0*	*8.0*	*6.0*	*5.0*	*5.0*
residential and non-residential total	553.0	493.3	430.0	368.5	287.3	232.7	199.1

Baseline scenario - BSL 2	2020	2025	2030	2035	2040	2045	2050
Energy impact							
Envelope measures							
heating, by type of building [TWh]							
Single family house	1278.0	1189.5	1089.3	985.8	887.4	796.1	713.4
Small multifamily house	249.0	230.1	208.8	186.8	165.8	146.1	128.1
Large multifamily house	265.9	243.6	218.7	193.8	170.8	149.7	130.7
office buildings	152.1	149.8	145.8	140.7	135.8	131.7	128.8
trade and retail buildings	177.0	173.4	167.7	160.8	154.1	148.3	144.0
educational buildings	172.8	172.7	170.8	168.1	165.8	164.8	165.8
tourism and heath building	111.5	108.6	104.4	99.4	94.4	89.8	86.0
other buildings	105.5	103.4	100.0	96.0	92.1	88.8	86.4
total residential	1792.9	1663.2	1516.7	1366.4	1223.9	1091.9	972.2
total non-residential	718.9	707.8	688.7	665.0	642.1	623.4	611.0
total residential and non-residential	2511.8	2371.0	2205.5	2031.5	1866.1	1715.3	1583.2
heating, by type of measure [TWh]							
not renovated	1699.2	1527.8	1343.9	1150.5	955.5	762.2	574.0
already renovated	789.4	696.7	581.5	465.6	361.9	270.7	187.6
renovation - average	16.4	105.1	202.8	300.7	394.7	487.1	582.2
renovation - ZEB partial-not renovated	0.0	0.0	0.0	0.0	0.0	0.0	0.0
renovation - ZEB partial-already renovated	0.0	0.0	0.0	0.0	0.0	0.0	0.0
renovation - ZEB restricted	0.0	0.0	0.0	0.0	0.0	0.0	0.0
renovation - ZEB	0.1	0.7	1.7	2.9	4.4	6.4	9.0
total existing buildings	2505.1	2330.3	2129.9	1919.8	1716.6	1526.3	1352.9
new building - nZEB standard (nearly-zero energy)	6.5	38.8	70.5	101.8	132.8	163.4	193.2
new building - ZEB standard (zero emission)	0.2	1.9	5.1	9.9	16.7	25.6	37.1
total new buildings	6.7	40.7	75.6	111.7	149.4	188.9	230.3
heating, by type of fuel [TWh]							
Coal	96.7	61.9	36.9	20.4	10.5	4.9	2.0
Oil	323.3	284.3	209.3	137.9	89.7	56.6	34.0
Gas	1246.2	1148.3	1050.7	921.0	760.9	603.5	466.9
District heating	248.4	291.7	345.9	408.0	474.4	541.9	606.9
Electricity	130.1	97.9	66.6	43.1	27.8	17.5	10.5
Solid biomass	428.7	424.3	401.3	374.2	351.3	324.9	294.1
Heat pumps	38.4	62.6	94.9	126.8	151.4	165.9	168.8
Hybrid heat pumps	0.0	0.0	0.0	0.0	0.0	0.0	0.0
total impact envelope + equipment [TWh]							
residential total	2076.6	1952.4	1807.6	1657.1	1514.7	1383.5	1266.4
heating	1792.9	1663.2	1516.7	1366.4	1223.9	1091.9	972.2
domestic hot water	252.0	256.8	257.9	257.3	256.9	257.6	260.0
cooling	31.7	32.4	33.0	33.4	33.8	34.1	34.2
non-residential total	842.4	835.5	819.9	799.4	779.8	764.9	757.4
heating	718.9	707.8	688.7	665.0	642.1	623.4	611.0
domestic hot water	73.3	75.8	77.7	79.3	81.3	83.9	87.5
cooling	50.2	51.9	53.5	55.0	56.4	57.7	58.9
residential and non-residential total	2919.1	2787.9	2627.5	2456.5	2294.5	2148.5	2023.8
Investment and energy costs							
Investment costs [bn Euro2020]							
total investment costs	146.8	167.0	189.2	199.4	210.0	221.4	233.4
total renovation of existing buildings	92.1	109.6	128.8	135.9	143.1	150.8	159.0
envelope	59.1	69.7	81.2	84.4	87.5	90.9	94.4
floor	6.1	7.2	8.4	8.7	9.0	9.3	9.7
roof	23.5	27.8	32.3	33.6	34.8	36.2	37.6
walls	18.7	21.9	25.4	26.3	27.2	28.1	29.1
windows	10.8	12.9	15.1	15.8	16.5	17.3	18.1
equipment	33.0	39.8	47.6	51.5	55.5	60.0	64.6
heating + domestic hot water system	28.0	32.7	37.9	39.5	41.1	42.6	44.1
ventilation system	5.1	7.2	9.7	12.0	14.5	17.4	20.5
total new buildings	54.6	57.4	60.3	63.5	66.9	70.5	74.4
envelope	44.6	46.7	48.9	51.3	53.7	56.4	59.2
floor	4.7	4.9	5.1	5.3	5.5	5.7	6.0
roof	17.5	18.4	19.3	20.3	21.3	22.4	23.6
walls	13.6	14.2	14.8	15.5	16.2	16.9	17.7
windows	8.8	9.3	9.7	10.3	10.8	11.4	12.0
equipment	10.0	10.7	11.4	12.3	13.2	14.1	15.2
heating + domestic hot water system	6.8	7.0	7.2	7.4	7.7	7.9	8.2
ventilation system	3.2	3.7	4.3	4.9	5.5	6.2	7.0
Energy costs [bn Euro2020]							
total energy costs for heating, cooling and domestic hot water	218.3	241.8	255.4	248.9	241.4	232.2	223.3
residential	175.7	195.3	204.8	198.0	189.9	179.5	170.3
non-residential	42.6	46.5	50.6	51.0	51.5	52.6	53.0
total heating energy costs	177.3	198.1	207.2	200.0	191.5	180.4	170.0
residential	145.6	162.7	169.1	161.7	152.8	141.8	131.2
non-residential	31.7	35.3	38.1	38.3	38.7	38.6	38.8
total domestic hot water costs	26.0	28.7	31.2	31.9	32.9	33.7	35.3
residential	23.1	25.5	27.7	28.3	29.1	29.8	31.1
non-residential	2.9	3.2	3.5	3.6	3.8	4.0	4.2
total cooling costs	15.0	15.0	17.0	17.0	17.0	18.0	18.0
residential	7.0	7.0	8.0	8.0	8.0	8.0	8.0
non-residential	8.0	8.0	9.0	9.0	9.0	10.0	10.0

Low ambition scenario - LOW							1
	2020	2025	2030	2035	2040	2045	2050
Building stock							
by type of building [bn m2]							
Single family house	*11.1*	*11.4*	*11.8*	*12.2*	*12.6*	*13.0*	*13.5*
Small multifamily house	*2.9*	*3.0*	*3.1*	*3.2*	*3.3*	*3.4*	*3.5*
Large multifamily house	*3.8*	*3.9*	*4.1*	*4.2*	*4.3*	*4.5*	*4.6*
office buildings	*1.5*	*1.6*	*1.7*	*1.7*	*1.8*	*1.9*	*2.0*
trade and retail buildings	*1.5*	*1.6*	*1.6*	*1.7*	*1.8*	*1.9*	*2.0*
educational buildings	*1.1*	*1.2*	*1.2*	*1.3*	*1.4*	*1.4*	*1.5*
tourism and heath building	*1.3*	*1.4*	*1.4*	*1.5*	*1.6*	*1.6*	*1.7*
other buildings	*0.9*	*0.9*	*1.0*	*1.0*	*1.1*	*1.2*	*1.2*
total residential	*17.8*	*18.4*	*19.0*	*19.6*	*20.2*	*20.9*	*21.5*
total non-residential	*6.3*	*6.6*	*7.0*	*7.3*	*7.7*	*8.1*	*8.5*
total residential and non-residential	24.1	25.0	25.9	26.9	27.9	29.0	30.1
by type of measure [bn m2]							
not renovated	*13.3*	*12.1*	*10.8*	*9.3*	*7.8*	*6.1*	*4.3*
already renovated	*10.3*	*9.5*	*8.3*	*6.9*	*5.4*	*4.0*	*2.6*
renovation - average	*0.3*	*2.1*	*4.5*	*7.1*	*9.8*	*12.7*	*15.6*
renovation - ZEB partial-not renovated	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
renovation - ZEB partial-already renovated	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
renovation - ZEB restricted	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
renovation - ZEB	*0.0*	*0.0*	*0.1*	*0.1*	*0.2*	*0.3*	*0.4*
total existing buildings	*23.9*	*23.8*	*23.6*	*23.4*	*23.3*	*23.1*	*22.9*
new building - nZEB standard (nearly-zero energy)	*0.2*	*1.1*	*2.0*	*2.9*	*3.7*	*4.5*	*5.2*
new building - ZEB standard (zero emission)	*0.0*	*0.1*	*0.3*	*0.5*	*0.9*	*1.4*	*2.0*
total new buildings	*0.2*	*1.2*	*2.3*	*3.4*	*4.6*	*5.9*	*7.2*
Average renovation rate in full renovation equivalent (over 5 yrs) [%total floor area]	*1.35%*	*1.47%*	*1.8%*	*2.1%*	*2.1%*	*2.1%*	*2.0%*
Average share of deeply renovated after 2020 (over 5 yrs) [% of total renovated area]	*1.00%*	*1.16%*	*1.4%*	*1.6%*	*1.9%*	*2.2%*	*2.5%*
Environmental impact							
heating, by type of building [Mt CO2 eq]							
Single family house	*222.8*	*192.3*	*159.3*	*125.6*	*88.4*	*64.0*	*48.9*
Small multifamily house	*44.6*	*39.3*	*33.9*	*28.5*	*22.0*	*17.0*	*13.5*
Large multifamily house	*45.7*	*39.9*	*34.2*	*28.5*	*21.5*	*16.5*	*13.0*
office buildings	*31.3*	*28.3*	*24.8*	*21.1*	*16.2*	*13.1*	*11.6*
trade and retail buildings	*36.7*	*32.9*	*28.6*	*24.1*	*18.2*	*14.7*	*12.9*
educational buildings	*35.4*	*32.2*	*28.5*	*24.6*	*19.1*	*15.9*	*14.5*
tourism and heath building	*22.9*	*20.4*	*17.5*	*14.5*	*10.8*	*8.4*	*7.1*
other buildings	*21.8*	*19.5*	*17.0*	*14.3*	*10.9*	*8.8*	*7.7*
total residential	*313.1*	*271.5*	*227.4*	*182.6*	*131.8*	*97.5*	*75.4*
total non-residential	*148.1*	*133.3*	*116.4*	*98.7*	*75.1*	*60.9*	*53.8*
total residential and non-residential	*461.1*	*404.8*	*343.8*	*281.2*	*207.0*	*158.4*	*129.1*
heating, by type of measure [Mt CO2 eq]							
not renovated	*312.5*	*260.7*	*206.9*	*153.8*	*98.4*	*60.9*	*35.1*
already renovated	*144.4*	*118.5*	*89.9*	*62.1*	*36.4*	*19.9*	*8.8*
renovation - average	*3.2*	*19.1*	*35.7*	*49.6*	*54.0*	*56.3*	*59.9*
renovation - ZEB partial-not renovated	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
renovation - ZEB partial-already renovated	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
renovation - ZEB restricted	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
renovation - ZEB	*0.0*	*0.1*	*0.3*	*0.5*	*0.6*	*0.7*	*0.9*
total existing buildings	*460.0*	*398.4*	*332.7*	*266.0*	*189.3*	*137.7*	*104.7*
new building - nZEB standard (nearly-zero energy)	*1.1*	*6.1*	*10.2*	*13.6*	*15.1*	*17.1*	*19.5*
new building - ZEB standard (zero emission)	*0.0*	*0.4*	*0.9*	*1.7*	*2.5*	*3.6*	*5.0*
total new buildings	*1.1*	*6.4*	*11.1*	*15.3*	*17.6*	*20.6*	*24.5*
heating, by type of fuel [Mt CO2 eq]							
Coal	*32.9*	*21.5*	*12.7*	*6.7*	*3.3*	*1.5*	*0.7*
Oil	*86.2*	*72.7*	*53.3*	*34.2*	*21.5*	*13.1*	*7.6*
Gas	*251.7*	*226.9*	*198.7*	*162.6*	*123.8*	*91.3*	*67.6*
District heating	*52.1*	*49.9*	*47.8*	*47.6*	*35.2*	*31.8*	*33.5*
Electricity	*30.8*	*20.6*	*11.9*	*6.2*	*2.5*	*1.3*	*0.7*
Solid biomass	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Heat pumps	*7.4*	*13.2*	*18.7*	*21.1*	*16.2*	*13.9*	*13.3*
Hybrid heat pumps	*0.0*	*0.0*	*0.7*	*2.8*	*4.5*	*5.5*	*5.8*
total impact [Mt CO2 eq]							
residential total	*373.3*	*326.2*	*276.1*	*226.2*	*166.2*	*126.8*	*103.0*
heating	*313.1*	*271.5*	*227.4*	*182.6*	*131.8*	*97.5*	*75.4*
domestic hot water	*50.3*	*45.7*	*41.7*	*37.6*	*30.4*	*26.3*	*24.6*
cooling	*10.0*	*9.0*	*7.0*	*6.0*	*4.0*	*3.0*	*3.0*
non-residential total	*179.7*	*161.3*	*140.8*	*119.5*	*91.4*	*74.9*	*67.5*
heating	*148.1*	*133.3*	*116.4*	*98.7*	*75.1*	*60.9*	*53.8*
domestic hot water	*17.6*	*16.0*	*14.4*	*12.8*	*10.2*	*9.0*	*8.7*
cooling	*14.0*	*12.0*	*10.0*	*8.0*	*6.0*	*5.0*	*5.0*
residential and non-residential total	*553.0*	*487.5*	*416.8*	*345.7*	*257.6*	*201.7*	*170.5*

Low ambition scenario - LOW	2020	2025	2030	2035	2040	2045	2050
Energy impact							
Envelope measures							
heating, by type of building [TWh]							
Single family house	*1278.0*	*1176.4*	*1041.7*	*893.1*	*756.4*	*638.8*	*537.7*
Small multifamily house	*249.0*	*230.8*	*210.2*	*188.2*	*167.1*	*147.3*	*129.1*
Large multifamily house	*265.9*	*244.5*	*220.4*	*195.5*	*172.2*	*150.9*	*131.5*
office buildings	*152.1*	*148.3*	*142.5*	*134.9*	*127.5*	*122.3*	*119.3*
trade and retail buildings	*177.0*	*171.6*	*164.0*	*154.2*	*144.8*	*138.0*	*133.6*
educational buildings	*172.8*	*170.6*	*166.3*	*160.1*	*154.6*	*152.0*	*152.2*
tourism and heath building	*111.5*	*107.0*	*100.8*	*93.0*	*85.4*	*79.2*	*74.5*
other buildings	*105.5*	*102.2*	*97.7*	*92.0*	*86.5*	*82.5*	*80.0*
total residential	*1792.9*	*1651.7*	*1472.3*	*1276.7*	*1095.8*	*937.0*	*798.3*
total non-residential	*718.9*	*699.7*	*671.2*	*634.2*	*598.8*	*574.0*	*559.6*
total residential and non-residential	*2511.8*	*2351.4*	*2143.5*	*1910.9*	*1694.6*	*1511.0*	*1358.0*
heating, by type of measure [TWh]							
not renovated	*1699.2*	*1512.0*	*1288.9*	*1046.3*	*810.6*	*591.1*	*383.4*
already renovated	*789.4*	*691.5*	*563.2*	*425.1*	*304.5*	*201.4*	*108.8*
renovation - average	*16.4*	*106.8*	*214.9*	*326.4*	*428.3*	*527.4*	*632.5*
renovation - ZEB partial-not renovated	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
renovation - ZEB partial-already renovated	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
renovation - ZEB restricted	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
renovation - ZEB	*0.1*	*0.7*	*1.7*	*3.1*	*4.8*	*6.9*	*9.8*
total existing buildings	*2505.1*	*2310.9*	*2068.6*	*1800.9*	*1548.1*	*1326.8*	*1134.5*
new building - nZEB standard (nearly-zero energy)	*6.5*	*38.3*	*68.7*	*97.6*	*125.3*	*151.5*	*176.0*
new building - ZEB standard (zero emission)	*0.2*	*2.2*	*6.2*	*12.4*	*21.1*	*32.7*	*47.4*
total new buildings	*6.7*	*40.5*	*74.9*	*110.0*	*146.4*	*184.2*	*223.5*
heating, by type of fuel [TWh]							
Coal	*96.7*	*63.2*	*37.2*	*19.7*	*9.7*	*4.5*	*1.9*
Oil	*323.3*	*272.5*	*199.8*	*128.2*	*80.4*	*48.9*	*28.5*
Gas	*1246.2*	*1123.5*	*983.7*	*805.3*	*612.9*	*452.1*	*334.8*
District heating	*248.4*	*291.9*	*343.1*	*396.7*	*447.9*	*493.3*	*528.5*
Electricity	*130.1*	*101.6*	*68.9*	*43.3*	*26.9*	*16.3*	*9.4*
Solid biomass	*428.7*	*429.2*	*398.1*	*357.0*	*319.6*	*283.3*	*246.6*
Heat pumps	*38.4*	*69.5*	*109.1*	*145.4*	*167.8*	*174.9*	*168.2*
Hybrid heat pumps	*0.0*	*0.0*	*3.6*	*15.4*	*29.4*	*37.8*	*40.1*
total impact [TWh]							
residential total	*2076.6*	*1940.5*	*1761.0*	*1562.4*	*1378.7*	*1219.0*	*1082.1*
heating	*1792.9*	*1651.7*	*1472.3*	*1276.7*	*1095.8*	*937.0*	*798.3*
domestic hot water	*252.0*	*256.4*	*255.8*	*252.2*	*249.1*	*247.9*	*249.6*
cooling	*31.7*	*32.4*	*33.0*	*33.4*	*33.8*	*34.1*	*34.2*
non-residential total	*842.4*	*828.6*	*803.8*	*769.2*	*736.2*	*714.8*	*705.2*
heating	*718.9*	*699.7*	*671.2*	*634.2*	*598.8*	*574.0*	*559.6*
domestic hot water	*73.3*	*77.0*	*79.0*	*80.0*	*81.0*	*83.1*	*86.7*
cooling	*50.2*	*51.9*	*53.5*	*55.0*	*56.4*	*57.7*	*58.9*
residential and non-residential total	*2919.1*	*2769.1*	*2564.8*	*2331.5*	*2114.9*	*1933.9*	*1787.3*
Investment and energy costs							
Investment costs [bn Euro2020]							
total investment costs	*146.8*	*181.1*	*222.4*	*239.1*	*250.4*	*262.0*	*274.2*
total renovation of existing buildings	*92.1*	*123.6*	*161.9*	*175.3*	*183.2*	*191.1*	*199.3*
envelope	*59.1*	*77.8*	*102.1*	*110.4*	*114.7*	*119.1*	*123.8*
floor	*6.1*	*8.0*	*10.6*	*11.4*	*11.9*	*12.3*	*12.8*
roof	*23.5*	*31.1*	*40.9*	*44.3*	*46.0*	*47.8*	*49.6*
walls	*18.7*	*24.2*	*31.5*	*33.9*	*35.1*	*36.3*	*37.6*
windows	*10.8*	*14.4*	*19.1*	*20.8*	*21.8*	*22.8*	*23.8*
equipment	*33.0*	*45.8*	*59.7*	*64.8*	*68.5*	*71.9*	*75.4*
heating + domestic hot water system	*28.0*	*34.6*	*41.4*	*44.3*	*46.0*	*47.2*	*48.4*
ventilation system	*5.1*	*11.2*	*18.4*	*20.5*	*22.5*	*24.7*	*27.0*
total new buildings	*54.6*	*57.5*	*60.5*	*63.8*	*67.3*	*71.0*	*75.0*
envelope	*44.6*	*46.8*	*49.1*	*51.6*	*54.2*	*56.9*	*59.8*
floor	*4.7*	*4.9*	*5.1*	*5.3*	*5.5*	*5.7*	*6.0*
roof	*17.5*	*18.4*	*19.3*	*20.3*	*21.4*	*22.5*	*23.7*
walls	*13.6*	*14.2*	*14.8*	*15.5*	*16.2*	*17.0*	*17.8*
windows	*8.8*	*9.3*	*9.9*	*10.4*	*11.0*	*11.7*	*12.3*
equipment	*10.0*	*10.7*	*11.4*	*12.2*	*13.1*	*14.1*	*15.2*
heating + domestic hot water system	*6.8*	*7.0*	*7.2*	*7.4*	*7.7*	*8.0*	*8.3*
ventilation system	*3.2*	*3.7*	*4.2*	*4.8*	*5.4*	*6.1*	*6.9*
Energy costs [bn Euro2020]							
total energy costs for heating, cooling and domestic hot water	*218.3*	*241.1*	*251.4*	*239.9*	*227.0*	*213.4*	*200.5*
residential	*175.7*	*194.5*	*200.7*	*189.0*	*175.9*	*161.5*	*148.7*
non-residential	*42.6*	*46.6*	*50.7*	*50.9*	*51.1*	*51.9*	*51.8*
total heating energy costs	*177.3*	*197.5*	*203.5*	*191.5*	*177.9*	*162.6*	*148.2*
residential	*145.6*	*161.9*	*165.1*	*152.9*	*139.3*	*124.4*	*110.3*
non-residential	*31.7*	*35.6*	*38.4*	*38.6*	*38.6*	*38.2*	*37.9*
total domestic hot water costs	*26.0*	*28.6*	*30.9*	*31.4*	*32.1*	*32.8*	*34.3*
residential	*23.1*	*25.5*	*27.6*	*28.0*	*28.6*	*29.1*	*30.4*
non-residential	*2.9*	*3.1*	*3.3*	*3.4*	*3.5*	*3.7*	*3.9*
total cooling costs	*15.0*	*15.0*	*17.0*	*17.0*	*17.0*	*18.0*	*18.0*
residential	*7.0*	*7.0*	*8.0*	*8.0*	*8.0*	*8.0*	*8.0*
non-residential	*8.0*	*8.0*	*9.0*	*9.0*	*9.0*	*10.0*	*10.0*

Moderate ambition scenario - MODERATE							1
	2020	2025	2030	2035	2040	2045	2050
Building stock							
by type of building [bn m2]							
Single family house	11.1	11.4	11.8	12.2	12.6	13.0	13.5
Small multifamily house	2.9	3.0	3.1	3.2	3.3	3.4	3.5
Large multifamily house	3.8	3.9	4.1	4.2	4.3	4.5	4.6
office buildings	1.5	1.6	1.7	1.7	1.8	1.9	2.0
trade and retail buildings	1.5	1.6	1.6	1.7	1.8	1.9	2.0
educational buildings	1.1	1.2	1.2	1.3	1.4	1.4	1.5
tourism and heath building	1.3	1.4	1.4	1.5	1.6	1.6	1.7
other buildings	0.9	0.9	1.0	1.0	1.1	1.2	1.2
total residential	17.8	18.4	19.0	19.6	20.2	20.9	21.5
total non-residential	6.3	6.6	7.0	7.3	7.7	8.1	8.5
total residential and non-residential	24.1	25.0	25.9	26.9	27.9	29.0	30.1
by type of measure [bn m2]							
not renovated	13.3	12.1	10.8	9.4	7.8	6.0	4.5
already renovated	10.3	9.5	8.3	6.9	5.5	4.0	2.8
renovation - average	0.3	2.2	4.4	6.9	9.2	11.6	14.0
renovation - ZEB partial-not renovated	0.0	0.0	0.0	0.0	0.0	0.0	0.0
renovation - ZEB partial-already renovated	0.0	0.0	0.0	0.0	0.0	0.0	0.0
renovation - ZEB restricted	0.0	0.0	0.0	0.0	0.1	0.2	0.2
renovation - ZEB	0.0	0.0	0.1	0.3	0.6	1.3	1.4
total existing buildings	23.9	23.8	23.6	23.4	23.3	23.1	22.9
new building - nZEB standard (nearly-zero energy)	0.2	1.1	1.9	2.6	3.2	3.8	4.3
new building - ZEB standard (zero emission)	0.0	0.1	0.3	0.8	1.3	2.0	2.7
total new buildings	0.2	1.2	2.3	3.4	4.5	5.7	7.0
Average renovation rate in full renovation equivalent (over 5 yrs) [%total floor area]	1.35%	1.47%	1.8%	2.0%	2.0%	2.2%	1.7%
Average share of deeply renovated after 2020 (over 5 yrs) [% of total renovated area]	1.00%	1.17%	1.6%	3.3%	6.0%	9.6%	10.8%
Environmental impact							
heating, by type of building [Mt CO2 eq]							
Single family house	222.8	192.1	158.7	124.7	87.5	63.1	47.9
Small multifamily house	44.6	39.3	33.9	28.4	21.9	17.0	13.4
Large multifamily house	45.7	39.8	34.0	28.3	21.2	16.2	12.8
office buildings	31.3	28.1	23.5	18.0	11.4	7.9	7.7
trade and retail buildings	36.7	32.6	27.2	20.7	13.1	8.9	9.2
educational buildings	35.4	32.2	28.4	24.5	19.0	15.9	14.6
tourism and heath building	22.9	20.3	17.4	14.4	10.7	8.4	7.1
other buildings	21.8	19.3	16.1	12.3	7.8	5.4	5.2
total residential	313.1	271.1	226.6	181.4	130.6	96.3	74.1
total non-residential	148.1	132.6	112.6	89.9	62.1	46.5	43.8
total residential and non-residential	461.1	403.7	339.2	271.2	192.7	142.7	117.8
heating, by type of measure [Mt CO2 eq]							
not renovated	312.5	259.9	205.0	150.6	94.7	57.1	35.8
already renovated	144.4	118.5	89.5	61.4	35.6	19.0	10.7
renovation - average	3.2	19.0	34.1	44.3	45.1	45.4	47.2
renovation - ZEB partial-not renovated	0.0	0.0	0.0	0.0	0.0	0.0	0.0
renovation - ZEB partial-already renovated	0.0	0.0	0.0	0.0	0.0	0.0	0.0
renovation - ZEB restricted	0.0	0.0	0.0	0.2	0.3	0.6	0.6
renovation - ZEB	0.0	0.1	0.4	1.3	2.2	3.6	3.7
total existing buildings	460.0	397.6	329.0	257.8	177.9	125.8	98.0
new building - nZEB standard (nearly-zero energy)	1.1	5.8	9.1	11.1	11.7	12.9	14.4
new building - ZEB standard (zero emission)	0.0	0.3	1.1	2.3	3.1	4.0	5.5
total new buildings	1.1	6.1	10.2	13.4	14.8	16.9	19.8
heating, by type of fuel [Mt CO2 eq]							
Coal	32.9	21.9	13.0	6.8	3.3	1.5	0.7
Oil	86.2	71.8	51.8	32.6	20.0	11.9	6.9
Gas	251.7	226.5	193.9	151.2	108.1	75.8	55.2
District heating	52.1	48.7	46.7	46.6	34.2	30.2	32.5
Electricity	30.8	20.9	11.8	5.9	2.3	1.1	0.6
Solid biomass	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heat pumps	7.4	13.9	21.0	24.0	18.1	14.8	14.0
Hybrid heat pumps	0.0	0.0	1.0	4.2	6.7	7.5	8.0
total impact envelope + equipment [Mt CO2 eq]							
residential total	373.3	325.7	275.1	224.7	164.8	125.4	101.4
heating	313.1	271.1	226.6	181.4	130.6	96.3	74.1
domestic hot water	50.3	45.6	41.5	37.3	30.1	26.1	24.3
cooling	10.0	9.0	7.0	6.0	4.0	3.0	3.0
non-residential total	179.7	160.5	136.7	110.1	77.4	59.5	56.6
heating	148.1	132.6	112.6	89.9	62.1	46.5	43.8
domestic hot water	17.6	15.9	14.1	12.3	9.3	8.0	7.9
cooling	14.0	12.0	10.0	8.0	6.0	5.0	5.0
residential and non-residential total	553.0	486.2	411.8	334.8	242.2	184.8	158.0

Moderate ambition scenario - MODERATE	2020	2025	2030	2035	2040	2045	2050
Energy impact							
Envelope measures							
heating, by type of building [TWh]							
Single family house	1278.0	1172.7	1034.7	883.8	745.5	626.7	524.7
Small multifamily house	249.0	230.6	209.9	187.8	166.6	146.7	128.4
Large multifamily house	265.9	243.8	219.1	193.8	170.2	148.5	128.8
office buildings	152.1	145.7	135.6	120.2	105.7	92.1	97.6
trade and retail buildings	177.0	168.6	156.6	138.6	121.8	104.1	112.0
educational buildings	172.8	170.4	165.9	159.4	153.8	151.1	151.2
tourism and heath building	111.5	106.8	100.4	92.5	84.7	78.4	73.5
other buildings	105.5	100.5	93.2	82.5	72.7	63.0	66.0
total residential	1792.9	1647.1	1463.7	1265.3	1082.3	921.9	781.9
total non-residential	718.9	692.1	651.7	593.2	538.8	488.7	500.3
total residential and non-residential	2511.8	2339.1	2115.4	1858.6	1621.1	1410.6	1282.2
heating, by type of measure [TWh]							
not renovated	1699.2	1503.9	1275.8	1029.7	796.0	566.9	397.2
already renovated	789.4	689.4	560.4	423.0	304.8	197.5	126.4
renovation - average	16.4	106.3	206.8	295.9	365.9	434.0	508.0
renovation - ZEB partial-not renovated	0.0	0.0	0.0	0.0	0.0	0.0	0.0
renovation - ZEB partial-already renovated	0.0	0.0	0.0	0.0	0.0	0.0	0.0
renovation - ZEB restricted	0.0	0.0	0.2	1.2	3.1	6.9	7.2
renovation - ZEB	0.1	0.7	2.2	8.9	20.1	41.9	45.6
total existing buildings	2505.1	2300.2	2045.3	1758.6	1489.8	1247.2	1084.2
new building - nZEB standard (nearly-zero energy)	6.5	37.1	62.4	81.5	99.2	115.9	131.2
new building - ZEB standard (zero emission)	0.2	1.8	7.6	18.5	32.0	47.5	66.7
total new buildings	6.7	38.9	70.1	100.0	131.2	163.4	198.0
heating, by type of fuel [TWh]							
Coal	96.7	64.3	38.1	20.1	9.7	4.4	1.9
Oil	323.3	269.2	194.1	122.1	74.9	44.6	25.7
Gas	1246.2	1121.7	960.0	748.7	535.0	375.1	273.5
District heating	248.4	286.9	339.7	395.1	445.7	480.1	525.3
Electricity	130.1	102.4	67.4	40.2	23.3	13.2	7.4
Solid biomass	428.7	422.3	390.9	348.4	307.2	263.7	226.0
Heat pumps	38.4	72.5	120.0	160.8	181.6	178.1	167.3
Hybrid heat pumps	0.0	0.0	5.3	23.2	43.6	51.4	55.0
total impact envelope + equipment [TWh]							
residential total	2076.6	1935.2	1751.2	1549.1	1362.7	1200.8	1061.8
heating	1792.9	1647.1	1463.7	1265.3	1082.3	921.9	781.9
domestic hot water	252.0	255.7	254.5	250.3	246.6	244.8	245.7
cooling	31.7	32.4	33.0	33.4	33.8	34.1	34.2
non-residential total	842.4	820.6	782.9	725.4	672.1	625.0	642.3
heating	718.9	692.1	651.7	593.2	538.8	488.7	500.3
domestic hot water	73.3	76.7	77.7	77.2	76.9	78.6	83.1
cooling	50.2	51.9	53.5	55.0	56.4	57.7	58.9
residential and non-residential total	2919.1	2755.9	2534.1	2274.5	2034.7	1825.8	1704.1
Investment and energy costs							
Investment costs [bn Euro2020]							
total investment costs	146.8	183.2	231.5	247.1	261.2	277.7	274.6
total renovation of existing buildings	92.1	127.2	170.4	184.5	192.3	208.5	197.9
envelope	59.1	78.9	102.1	110.9	115.0	128.0	113.9
floor	6.1	8.1	10.5	11.3	11.7	13.1	11.4
roof	23.5	31.4	40.7	44.2	45.8	51.6	44.6
walls	18.7	24.5	31.6	34.0	35.2	37.8	36.0
windows	10.8	14.8	19.3	21.4	22.3	25.5	21.8
equipment	33.0	48.4	68.4	73.6	77.3	80.5	84.0
heating + domestic hot water system	28.0	35.4	43.8	46.9	48.6	49.6	50.8
ventilation system	5.1	13.0	24.6	26.6	28.7	30.9	33.3
total new buildings	54.6	56.0	61.1	62.6	69.0	69.2	76.8
envelope	44.6	46.1	48.7	51.2	53.7	56.4	59.2
floor	4.7	4.8	5.0	5.2	5.4	5.6	5.8
roof	17.5	18.1	19.2	20.2	21.3	22.4	23.5
walls	13.6	14.0	14.7	15.4	16.1	16.8	17.6
windows	8.8	9.2	9.8	10.4	11.0	11.6	12.3
equipment	10.0	9.8	12.4	11.5	15.3	12.9	17.6
heating + domestic hot water system	6.8	6.9	7.5	7.5	8.3	7.9	8.7
ventilation system	3.2	2.9	4.9	4.0	7.0	5.0	8.9
Energy costs [bn Euro2020]							
total energy costs for heating, cooling and domestic hot water	218.3	240.9	251.0	238.7	224.6	208.6	197.0
residential	175.7	194.2	200.2	188.1	174.8	160.2	147.1
non-residential	42.6	46.7	50.8	50.6	49.9	48.5	49.9
total heating energy costs	177.3	197.3	203.2	190.5	175.7	158.1	145.0
residential	145.6	161.7	164.6	152.2	138.3	123.3	109.0
non-residential	31.7	35.6	38.6	38.3	37.4	34.8	36.0
total domestic hot water costs	26.0	28.6	30.8	31.3	31.9	32.5	34.0
residential	23.1	25.5	27.5	27.9	28.4	28.9	30.1
non-residential	2.9	3.1	3.3	3.4	3.5	3.7	3.9
total cooling costs	15.0	15.0	17.0	17.0	17.0	18.0	18.0
residential	7.0	7.0	8.0	8.0	8.0	8.0	8.0
non-residential	8.0	8.0	9.0	9.0	9.0	10.0	10.0

High ambition I scenario - HIGH-I	2020	2025	2030	2035	2040	2045	2050
Building stock							
by type of building [bn m2]							
Single family house	11.1	11.4	11.8	12.2	12.6	13.0	13.5
Small multifamily house	2.9	3.0	3.1	3.2	3.3	3.4	3.5
Large multifamily house	3.8	3.9	4.1	4.2	4.3	4.5	4.6
office buildings	1.5	1.6	1.7	1.7	1.8	1.9	2.0
trade and retail buildings	1.5	1.6	1.6	1.7	1.8	1.9	2.0
educational buildings	1.1	1.2	1.2	1.3	1.4	1.4	1.5
tourism and heath building	1.3	1.4	1.4	1.5	1.6	1.6	1.7
other buildings	0.9	0.9	1.0	1.0	1.1	1.2	1.2
total residential	17.8	18.4	19.0	19.6	20.2	20.9	21.5
total non-residential	6.3	6.6	7.0	7.3	7.7	8.1	8.5
total residential and non-residential	24.1	25.0	25.9	26.9	27.9	29.0	30.1
by type of measure [bn m2]							
not renovated	13.3	11.9	9.3	6.7	4.4	2.6	1.8
already renovated	10.3	9.8	8.3	6.1	3.6	1.9	1.2
renovation - average	0.3	2.1	5.6	7.8	7.8	7.8	7.8
renovation - ZEB partial-not renovated	0.0	0.0	0.1	1.3	2.9	3.3	2.4
renovation - ZEB partial-already renovated	0.0	0.0	0.0	0.0	0.0	0.0	0.0
renovation - ZEB restricted	0.0	0.0	0.0	0.5	1.4	2.3	3.1
renovation - ZEB	0.0	0.0	0.1	1.1	3.1	5.1	6.5
total existing buildings	23.9	23.8	23.6	23.4	23.3	23.1	22.9
new building - nZEB standard (nearly-zero energy)	0.2	1.2	1.8	1.8	1.8	1.8	1.8
new building - ZEB standard (zero emission)	0.0	0.0	0.5	1.6	2.8	4.1	5.4
total new buildings	0.2	1.2	2.3	3.4	4.6	5.9	7.2
Average renovation rate in full renovation equivalent (over 5 yrs) [%total floor area]	1.35%	1.47%	3.0%	3.6%	3.3%	2.3%	0.9%
Average share of deeply renovated after 2020 (over 5 yrs) [% of total renovated area]	1.00%	1.23%	3.9%	18.9%	39.6%	53.6%	59.2%
Environmental impact							
heating, by type of building [Mt CO2 eq]							
Single family house	222.8	177.7	117.5	76.2	48.1	33.4	25.7
Small multifamily house	44.6	35.8	23.2	13.9	7.6	4.7	2.8
Large multifamily house	45.7	35.8	23.1	14.0	7.7	4.8	2.7
office buildings	31.3	27.7	22.4	16.5	10.4	7.3	7.0
trade and retail buildings	36.7	32.1	25.9	19.1	12.0	8.4	8.1
educational buildings	35.4	31.5	25.2	18.4	11.5	9.4	9.1
tourism and heath building	22.9	19.8	15.0	10.2	5.8	4.6	4.4
other buildings	21.8	19.1	15.3	11.3	7.1	5.0	4.8
total residential	313.1	249.3	163.9	104.0	63.5	42.9	31.3
total non-residential	148.1	130.1	103.9	75.4	46.7	34.6	33.4
total residential and non-residential	461.1	379.4	267.8	179.4	110.3	77.6	64.7
heating, by type of measure [Mt CO2 eq]							
not renovated	312.5	239.4	143.8	72.2	30.4	14.5	9.9
already renovated	144.4	116.1	76.3	39.8	14.9	6.2	4.5
renovation - average	3.2	17.7	35.6	35.5	23.1	17.7	16.2
renovation - ZEB partial-not renovated	0.0	0.3	2.4	16.9	23.3	18.6	11.2
renovation - ZEB partial-already renovated	0.0	0.0	0.0	0.0	0.0	0.0	0.0
renovation - ZEB restricted	0.0	0.0	0.2	1.3	2.4	2.9	3.5
renovation - ZEB	0.0	0.1	0.5	3.3	6.0	7.2	7.6
total existing buildings	460.0	373.5	258.9	168.9	100.1	67.1	52.8
new building - nZEB standard (nearly-zero energy)	1.1	5.7	7.5	7.0	5.9	5.6	5.6
new building - ZEB standard (zero emission)	0.0	0.1	1.4	3.5	4.2	4.9	6.3
total new buildings	1.1	5.9	8.9	10.5	10.1	10.5	11.9
heating, by type of fuel [Mt CO2 eq]							
Coal	32.9	23.7	11.9	5.0	2.0	0.8	0.3
Oil	86.2	65.0	37.3	18.8	9.2	4.3	2.0
Gas	251.7	207.6	140.2	80.5	43.2	24.8	16.6
District heating	52.1	40.1	31.6	26.4	16.7	13.4	13.5
Electricity	30.8	26.3	18.2	11.6	5.5	2.8	1.5
Solid biomass	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heat pumps	7.4	16.7	26.3	29.2	21.3	17.3	16.2
Hybrid heat pumps	0.0	0.0	2.2	8.1	12.3	14.1	14.6
total impact envelope + equipment [Mt CO2 eq]							
residential total	373.3	300.8	204.6	135.6	84.6	59.8	48.1
heating	313.1	249.3	163.9	104.0	63.5	42.9	31.3
domestic hot water	50.3	42.5	33.8	25.6	17.0	13.9	13.8
cooling	10.0	9.0	7.0	6.0	4.0	3.0	3.0
non-residential total	179.7	157.8	127.2	94.1	60.1	45.8	44.5
heating	148.1	130.1	103.9	75.4	46.7	34.6	33.4
domestic hot water	17.6	15.7	13.3	10.7	7.4	6.1	6.1
cooling	14.0	12.0	10.0	8.0	6.0	5.0	5.0
residential and non-residential total	553.0	458.7	331.8	229.7	144.7	105.6	92.6

High ambition I scenario - HIGH-I							2
	2020	2025	2030	2035	2040	2045	2050
Energy impact							
Envelope measures							
heating, by type of building [TWh]							
Single family house	1278.0	1169.6	933.4	762.5	668.1	559.7	444.6
Small multifamily house	249.0	222.9	172.9	131.3	101.9	73.7	43.9
Large multifamily house	265.9	238.4	186.2	142.4	110.6	78.8	44.3
office buildings	152.1	144.5	133.3	117.9	103.8	88.8	88.4
trade and retail buildings	177.0	166.9	153.6	135.8	119.6	101.5	101.7
educational buildings	172.8	166.4	152.2	133.6	116.8	115.7	117.3
tourism and heath building	111.5	104.0	90.2	74.0	58.8	57.1	56.5
other buildings	105.5	99.5	91.5	80.8	71.3	60.7	60.7
total residential	1792.9	1630.9	1292.4	1036.2	880.5	712.2	532.8
total non-residential	718.9	681.3	620.7	542.1	470.3	423.7	424.6
total residential and non-residential	2511.8	2312.2	1913.1	1578.3	1350.8	1135.9	957.3
heating, by type of measure [TWh]							
not renovated	1699.2	1459.5	1031.4	635.0	363.7	199.2	131.8
already renovated	789.4	711.3	550.9	356.0	188.2	94.1	64.2
renovation - average	16.4	101.4	244.1	303.3	276.3	255.9	239.9
renovation - ZEB partial-not renovated	0.0	1.6	18.0	160.7	315.8	309.1	195.8
renovation - ZEB partial-already renovated	0.0	0.0	0.0	0.0	0.0	0.0	0.0
renovation - ZEB restricted	0.0	0.1	1.2	11.4	30.7	46.6	57.5
renovation - ZEB	0.1	0.4	3.3	26.3	68.1	99.4	109.7
total existing buildings	2505.1	2274.3	1848.9	1492.8	1242.8	1004.4	798.9
new building - nZEB standard (nearly-zero energy)	6.5	37.0	53.5	54.3	54.3	54.3	54.3
new building - ZEB standard (zero emission)	0.2	0.9	10.7	31.3	53.7	77.2	104.1
total new buildings	6.7	37.9	64.2	85.5	108.0	131.5	158.4
heating, by type of fuel [TWh]							
Coal	96.7	69.7	35.0	14.6	6.0	2.4	0.9
Oil	323.3	243.6	139.9	70.3	34.7	16.3	7.5
Gas	1246.2	1027.8	694.1	398.7	214.0	122.8	82.3
District heating	248.4	232.8	224.3	217.5	212.6	209.5	214.5
Electricity	130.1	133.3	109.4	84.3	61.1	37.4	19.8
Solid biomass	428.7	520.4	550.1	549.9	522.3	431.7	323.8
Heat pumps	38.4	84.7	149.2	198.3	220.8	219.2	207.9
Hybrid heat pumps	0.0	0.0	11.1	44.7	79.4	96.6	100.7
total impact envelope + equipment [TWh]							
residential total	2076.6	1918.2	1572.1	1303.7	1139.5	965.4	782.1
heating	1792.9	1630.9	1292.4	1036.2	880.5	712.2	532.8
domestic hot water	252.0	254.9	246.7	234.1	225.2	219.1	215.2
cooling	31.7	32.4	33.0	33.4	33.8	34.1	34.2
non-residential total	842.4	808.3	748.1	668.2	596.0	551.0	555.3
heating	718.9	681.3	620.7	542.1	470.3	423.7	424.6
domestic hot water	73.3	75.1	73.9	71.0	69.3	69.6	71.9
cooling	50.2	51.9	53.5	55.0	56.4	57.7	58.9
residential and non-residential total	2919.1	2726.5	2320.2	1971.9	1735.5	1516.4	1337.5
Investment and energy costs							
Investment costs [bn Euro2020]							
total investment costs	146.8	204.2	341.1	382.4	400.9	407.4	408.8
total renovation of existing buildings	92.1	147.2	275.6	314.8	325.4	333.1	325.6
envelope	59.1	89.1	178.8	213.4	221.3	226.4	215.6
floor	6.1	9.1	18.4	26.3	27.3	27.6	26.5
roof	23.5	35.3	72.3	117.1	121.4	123.4	118.9
walls	18.7	28.2	53.3	37.8	39.1	40.3	38.7
windows	10.8	16.5	34.8	32.3	33.5	35.1	31.5
equipment	33.0	58.1	96.8	101.4	104.1	106.7	110.0
heating + domestic hot water system	28.0	41.6	61.7	64.7	65.7	66.6	68.0
ventilation system	5.1	16.5	35.1	36.7	38.4	40.1	42.0
total new buildings	54.6	57.0	65.6	67.6	75.5	74.3	83.3
envelope	44.6	46.6	51.0	54.2	56.6	59.2	61.9
floor	4.7	4.9	4.9	5.0	5.2	5.5	5.7
roof	17.5	18.3	20.1	21.5	22.5	23.5	24.6
walls	13.6	14.1	15.3	16.2	16.8	17.5	18.3
windows	8.8	9.2	10.7	11.6	12.1	12.6	13.2
equipment	10.0	10.3	14.6	13.4	18.9	15.2	21.4
heating + domestic hot water system	6.8	7.2	8.4	8.2	9.4	8.5	9.4
ventilation system	3.2	3.1	6.1	5.2	9.5	6.7	12.0
Energy costs [bn Euro2020]							
total energy costs for heating, cooling and domestic hot water	218.3	241.9	235.1	213.3	198.0	180.2	161.6
residential	175.7	193.9	182.2	161.4	148.5	132.2	112.8
non-residential	42.6	48.0	52.9	52.0	49.5	48.0	48.8
total heating energy costs	177.3	198.3	188.0	166.8	151.4	131.5	111.7
residential	145.6	161.4	147.5	127.2	114.3	97.2	76.6
non-residential	31.7	36.9	40.5	39.6	37.1	34.4	35.0
total domestic hot water costs	26.0	28.6	30.0	29.6	29.7	30.7	32.0
residential	23.1	25.5	26.7	26.2	26.2	27.1	28.2
non-residential	2.9	3.1	3.3	3.4	3.4	3.6	3.8
total cooling costs	15.0	15.0	17.0	17.0	17.0	18.0	18.0
residential	7.0	7.0	8.0	8.0	8.0	8.0	8.0
non-residential	8.0	8.0	9.0	9.0	9.0	10.0	10.0

High ambition II scenario - HIGH-II							1
	2020	2025	2030	2035	2040	2045	2050
Building stock							
by type of building [bn m2]							
Single family house	11.1	11.4	11.8	12.2	12.6	13.0	13.5
Small multifamily house	2.9	3.0	3.1	3.2	3.3	3.4	3.5
Large multifamily house	3.8	3.9	4.1	4.2	4.3	4.5	4.6
office buildings	1.5	1.6	1.7	1.7	1.8	1.9	2.0
trade and retail buildings	1.5	1.6	1.6	1.7	1.8	1.9	2.0
educational buildings	1.1	1.2	1.2	1.3	1.4	1.4	1.5
tourism and heath building	1.3	1.4	1.4	1.5	1.6	1.6	1.7
other buildings	0.9	0.9	1.0	1.0	1.1	1.2	1.2
total residential	17.8	18.4	19.0	19.6	20.2	20.9	21.5
total non-residential	6.3	6.6	7.0	7.3	7.7	8.1	8.5
total residential and non-residential	24.1	25.0	25.9	26.9	27.9	29.0	30.1
by type of measure [bn m2]							
not renovated	13.3	11.9	9.3	6.7	4.4	2.6	1.8
already renovated	10.3	9.8	8.3	6.1	3.6	1.9	1.2
renovation - average	0.3	2.1	5.6	7.8	7.8	7.8	7.8
renovation - ZEB partial-not renovated	0.0	0.0	0.1	1.3	2.9	3.3	2.4
renovation - ZEB partial-already renovated	0.0	0.0	0.0	0.0	0.0	0.0	0.0
renovation - ZEB restricted	0.0	0.0	0.0	0.5	1.4	2.3	3.1
renovation - ZEB	0.0	0.0	0.1	1.1	3.1	5.1	6.5
total existing buildings	23.9	23.8	23.6	23.4	23.3	23.1	22.9
new building - nZEB standard (nearly-zero energy)	0.2	1.2	1.8	1.8	1.8	1.8	1.8
new building - ZEB standard (zero emission)	0.0	0.0	0.5	1.6	2.8	4.1	5.4
total new buildings	0.2	1.2	2.3	3.4	4.6	5.9	7.2
Average renovation rate in full renovation equivalent (over 5 yrs) [% of total floor area]	-	1.5%	3.0%	3.6%	3.3%	2.3%	0.9%
Average share of deeply renovated in total renovated floor area after 2020 (over 5 yrs) [% of total renovated area]	-	1.2%	3.9%	18.9%	39.6%	53.6%	59.2%
Environmental impact							
heating, by type of building [Mt CO2 eq]							
Single family house	222.8	173.6	108.0	67.1	41.8	29.4	23.1
Small multifamily house	44.6	35.0	21.4	12.3	6.8	4.3	2.6
Large multifamily house	45.7	35.2	21.6	12.7	7.0	4.4	2.5
office buildings	31.3	27.0	20.4	14.3	8.9	6.5	6.4
trade and retail buildings	36.7	31.4	23.6	16.5	10.3	7.4	7.4
educational buildings	35.4	30.8	23.1	16.1	10.0	8.4	8.4
tourism and heath building	22.9	19.4	13.7	8.8	5.0	4.0	4.0
other buildings	21.8	18.6	14.0	9.8	6.1	4.4	4.4
total residential	313.1	243.9	150.9	92.2	55.5	38.1	28.3
total non-residential	148.1	127.2	94.8	65.5	40.3	30.7	30.5
total residential and non-residential	461.1	371.0	245.7	157.7	95.9	68.8	58.7
heating, by type of measure [Mt CO2 eq]							
not renovated	312.5	233.7	130.7	62.5	26.3	12.7	8.8
already renovated	144.4	113.7	70.3	34.6	12.5	5.3	3.9
renovation - average	3.2	17.4	33.0	31.3	19.8	15.3	14.4
renovation - ZEB partial-not renovated	0.0	0.2	2.2	14.8	20.0	16.2	10.0
renovation - ZEB partial-already renovated	0.0	0.0	0.0	0.0	0.0	0.0	0.0
renovation - ZEB restricted	0.0	0.0	0.2	1.1	2.0	2.5	3.1
renovation - ZEB	0.0	0.1	0.5	2.9	5.1	6.2	6.7
total existing buildings	460.0	365.2	236.8	147.2	85.7	58.3	46.8
new building - nZEB standard (nearly-zero energy)	1.1	5.7	7.5	7.0	5.9	5.6	5.6
new building - ZEB standard (zero emission)	0.0	0.1	1.4	3.5	4.2	4.9	6.3
total new buildings	1.1	5.9	8.9	10.5	10.1	10.5	11.9
heating, by type of fuel [Mt CO2 eq]							
Coal	32.9	23.7	11.6	4.6	1.8	0.7	0.3
Oil	86.2	62.9	34.0	16.1	7.5	3.4	1.5
Gas	251.7	197.9	114.7	56.6	28.2	15.2	9.6
District heating	52.1	40.1	31.2	25.5	16.0	13.0	13.1
Electricity	30.8	26.3	18.1	11.3	5.2	2.6	1.4
Solid biomass	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heat pumps	7.4	20.2	33.9	35.2	23.8	18.5	17.0
Hybrid heat pumps	0.0	0.0	2.2	8.5	13.3	15.3	15.8
total impact envelope + equipment [Mt CO2 eq]							
residential total	373.3	294.8	189.9	121.9	75.1	53.9	44.3
heating	313.1	243.9	150.9	92.2	55.5	38.1	28.3
domestic hot water	50.3	41.9	32.0	23.7	15.6	12.9	13.0
cooling	10.0	9.0	7.0	6.0	4.0	3.0	3.0
non-residential total	179.7	154.7	117.3	83.2	52.9	41.4	41.2
heating	148.1	127.2	94.8	65.5	40.3	30.7	30.5
domestic hot water	17.6	15.5	12.5	9.7	6.6	5.6	5.7
cooling	14.0	12.0	10.0	8.0	6.0	5.0	5.0
residential and non-residential total	553.0	449.4	307.2	205.1	128.1	95.3	85.5

High ambition II scenario - HIGH-II

2

	2020	2025	2030	2035	2040	2045	2050
Energy impact							
heating, by type of building [TWh]							
Single family house	1278.0	1150.7	889.9	719.3	634.7	535.2	427.2
Small multifamily house	249.0	219.2	164.0	123.6	96.9	70.6	42.2
Large multifamily house	265.9	235.3	178.6	135.8	106.1	76.0	42.8
office buildings	152.1	141.5	124.1	107.8	97.0	84.8	85.5
trade and retail buildings	177.0	163.4	142.9	124.3	112.1	97.2	98.7
educational buildings	172.8	163.1	142.5	123.5	110.2	111.0	113.9
tourism and heath building	111.5	101.8	83.9	67.8	55.2	54.5	54.5
other buildings	105.5	97.5	85.3	74.1	66.8	58.2	58.8
total residential	1792.9	1605.2	1232.5	978.7	837.7	681.8	512.2
total non-residential	718.9	667.3	578.8	497.6	441.4	405.7	411.4
total residential and non-residential	2511.8	2272.5	1811.3	1476.3	1279.0	1087.5	923.6
heating, by type of measure [TWh]							
not renovated	1699.2	1432.8	970.9	589.1	342.7	189.9	126.4
already renovated	789.4	699.8	522.8	331.8	176.5	89.1	61.4
renovation - average	16.4	99.9	231.9	283.8	260.5	243.6	229.7
renovation - ZEB partial-not renovated	0.0	1.6	17.2	151.1	298.5	294.5	187.5
renovation - ZEB partial-already renovated	0.0	0.0	0.0	0.0	0.0	0.0	0.0
renovation - ZEB restricted	0.0	0.1	1.2	10.7	29.0	44.4	55.0
renovation - ZEB	0.1	0.4	3.1	24.3	63.8	94.5	105.2
total existing buildings	2505.1	2234.6	1747.1	1390.8	1171.0	956.0	765.2
new building - nZEB standard (nearly-zero energy)	6.5	37.0	53.5	54.3	54.3	54.3	54.3
new building - ZEB standard (zero emission)	0.2	0.9	10.7	31.3	53.7	77.2	104.1
total new buildings	6.7	37.9	64.2	85.5	108.0	131.5	158.4
heating, by type of fuel [TWh]							
Coal	96.7	69.5	34.2	13.6	5.4	2.1	0.8
Oil	323.3	235.6	127.4	60.3	28.2	12.8	5.7
Gas	1246.2	979.9	568.1	280.2	139.5	75.3	47.5
District heating	248.4	232.4	221.3	210.5	204.4	202.9	209.7
Electricity	130.1	133.3	108.8	82.4	58.6	35.2	18.3
Solid biomass	428.7	520.2	547.7	541.1	508.7	418.4	313.9
Heat pumps	38.4	101.5	192.6	241.3	248.4	235.6	218.6
Hybrid heat pumps	0.0	0.0	11.2	46.9	85.8	105.1	109.1
total impact envelope + equipment [TWh]							
residential total	2076.6	1888.9	1502.5	1236.1	1088.4	928.2	755.8
heating	1792.9	1605.2	1232.5	978.7	837.7	681.8	512.2
domestic hot water	252.0	251.3	237.0	223.9	216.9	212.3	209.3
cooling	31.7	32.4	33.0	33.4	33.8	34.1	34.2
non-residential total	842.4	792.9	702.2	619.1	563.7	530.5	540.1
heating	718.9	667.3	578.8	497.6	441.4	405.7	411.4
domestic hot water	73.3	73.8	69.9	66.5	65.9	67.1	69.8
cooling	50.2	51.9	53.5	55.0	56.4	57.7	58.9
residential and non-residential total	2919.1	2681.8	2204.7	1855.1	1652.1	1458.7	1295.9
Investment and energy costs							
Investment costs [bn Euro2020]							
total investment costs	146.8	205.0	346.5	389.9	410.1	417.8	420.6
total renovation of existing buildings	92.1	148.0	280.9	322.3	334.6	343.5	337.3
envelope	59.1	89.6	180.1	216.1	224.9	230.9	221.0
floor	6.1	9.2	18.5	26.6	27.7	28.1	27.1
roof	23.5	35.5	72.9	118.4	123.2	125.6	121.6
walls	18.7	28.4	53.9	38.4	40.0	41.5	40.1
windows	10.8	16.5	34.7	32.7	34.0	35.7	32.2
equipment	33.0	58.4	100.8	106.2	109.6	112.7	116.3
heating + domestic hot water system	28.0	41.9	62.6	66.2	67.8	68.9	70.5
ventilation system	5.1	16.5	38.3	40.0	41.9	43.8	45.8
total new buildings	54.6	57.0	65.6	67.6	75.5	74.3	83.3
envelope	44.6	46.6	51.0	54.2	56.6	59.2	61.9
floor	4.7	4.9	4.9	5.0	5.2	5.5	5.7
roof	17.5	18.3	20.1	21.5	22.5	23.5	24.6
walls	13.6	14.1	15.3	16.2	16.8	17.5	18.3
windows	8.8	9.2	10.7	11.6	12.1	12.6	13.2
equipment	10.0	10.3	14.6	13.4	18.9	15.2	21.4
heating + domestic hot water system	6.8	7.2	8.4	8.2	9.4	8.5	9.4
ventilation system	3.2	3.1	6.1	5.2	9.5	6.7	12.0
Energy costs [bn Euro2020]							
total energy costs for heating, cooling and domestic hot wat	218.3	241.3	232.7	210.4	195.2	178.0	160.1
residential	175.7	193.0	179.3	157.9	145.4	129.8	111.0
non-residential	42.6	48.3	53.3	52.4	49.8	48.2	49.1
total heating energy costs	177.3	197.7	185.9	164.1	148.8	129.5	110.3
residential	145.6	160.6	144.9	124.1	111.5	94.9	75.0
non-residential	31.7	37.1	41.0	40.1	37.3	34.6	35.3
total domestic hot water costs	26.0	28.6	29.8	29.2	29.4	30.5	31.8
residential	23.1	25.4	26.4	25.9	26.0	26.9	28.0
non-residential	2.9	3.1	3.4	3.4	3.4	3.6	3.8
total cooling costs	15.0	15.0	17.0	17.0	17.0	18.0	18.0
residential	7.0	7.0	8.0	8.0	8.0	8.0	8.0
non-residential	8.0	8.0	9.0	9.0	9.0	10.0	10.0

9. Modelling of the EPBD revision within the DEGD framework.

For the purpose of assessment the impacts of the EPBD revision within the "Delivering European Green Deal" (DEGD) framework (informally also called "Fit for 55") MIXwoEPBD variant was developed with the model PRIMES. This variant is built on the DEGD central MIX scenario.

DEGD central MIX scenario illustrates a balanced pathway towards the climate target of 55% GHG reduction by combination of carbon pricing and regulatory tools. In this scenario, drivers illustrating the revision of EPBD are present. Full description of MIX scenario, its baseline (REF2020) and its key results is available as part of DEGD package[70].

MIXwoEPBD variant was developped to assess the impacts of the revision of EPBD only (or more precisely of the absence of such a revision) rather than of the whole package of DEGD policies. This variant removes typical drivers representing the revision of EPBD:

1. Part of increase (between MIX and REF2020) in the rate and depth of renovations. Consequently, part of the increase in deep and medium does not happen or becomes light renovations only in this variant. This aspect has the biggest impact on the results.

   Importantly, renovations increase (between MIX and REF2020) are incentivised not only by drivers illustrating the revision of EPBD but also the horizontal energy savings obligation (under Article 8 of the EED recast) and the carbon price (but this is assumed static in the MIXwoEPBD variant at the level of the MIX scenario). Reflecting policy options of this IA, an increase of deep renovations (thanks to introduction of deep renovation standard) and part of increase of medium renovations (thanks to introduction of MEPs and obligation for application of MEPs for buildings under transaction) can be assigned to the revision of EPBD. Table below summarises the differences in renovation rates assumed in MIX and MIXwoEPBD scenarios.

[70] See the description of core scenarios here: https://ec.europa.eu/energy/data-analysis/energy-modelling/policy-scenarios-delivering-european-green-deal_en as well as Annex 4 in the Impact Assessment accompanying amendment to Renewable Energy Directive SWD(2021)621 final

Table D.9: Renovation rates in MIX and MIXwoEPBD scenarios

Average annual renovation rates for period 2026-30 (%)	Residential sector MIX	Residential sector MIX woEPBD	Services sector MIX	Services sector MIX woEPBD
Annual renovation rate as % of housing stock	**2.06**	**1.49**	**1.20**	**0.94**
Light Renovation (Windows) - R1	0.12	0.20	0.00	0.00
Light Renovation (Windows) - R2	0.12	0.19	0.08	0.08
Medium Renovation (Windows, Wall) - R3	0.10	0.17	0.20	0.20
Medium Renovation (Windows, Wall, Roof) - R4	0.12	0.26	0.20	0.18
Medium Renovation (Windows, Wall, Roof, Basement) - R5	0.22	0.18	0.52	0.35
Medium Renovation (Windows, Wall, Roof, Basement) - R6	0.33	0.19	0.07	0.05
Deep Renovation (Windows, Wall, Roof, Basement) - R7	0.49	0.18	0.06	0.04
Deep Renovation (Windows, Wall, Roof, Basement) - R8	0.63	0.15	0.05	0.03
Energy savings from renovations (%) space heating	**61.09**	**48.84**	**41.85**	**37.39**

Source: Primes

2. An increased rate of uptake of renewable H&C solutions (notably heat pumps) accompanying the renovations. Such equipment change becomes an attractive choice for low energy consumption of a deeply renovated building.

3. More stringent and better enforced standards for new buildings thanks to introduction of Long Term Renovation Strategies and ZEB standard definition.

4. Enabling conditions created by legal certainty about the measures described above and additional actions such as Buildings Renovation Passport aiming at increasing consumer awareness. In modelling terms, such enabling conditions translate into more frequent investment decisions as economic agents have full information about costs and benefits expected and in general perceive a lower transactional costs.

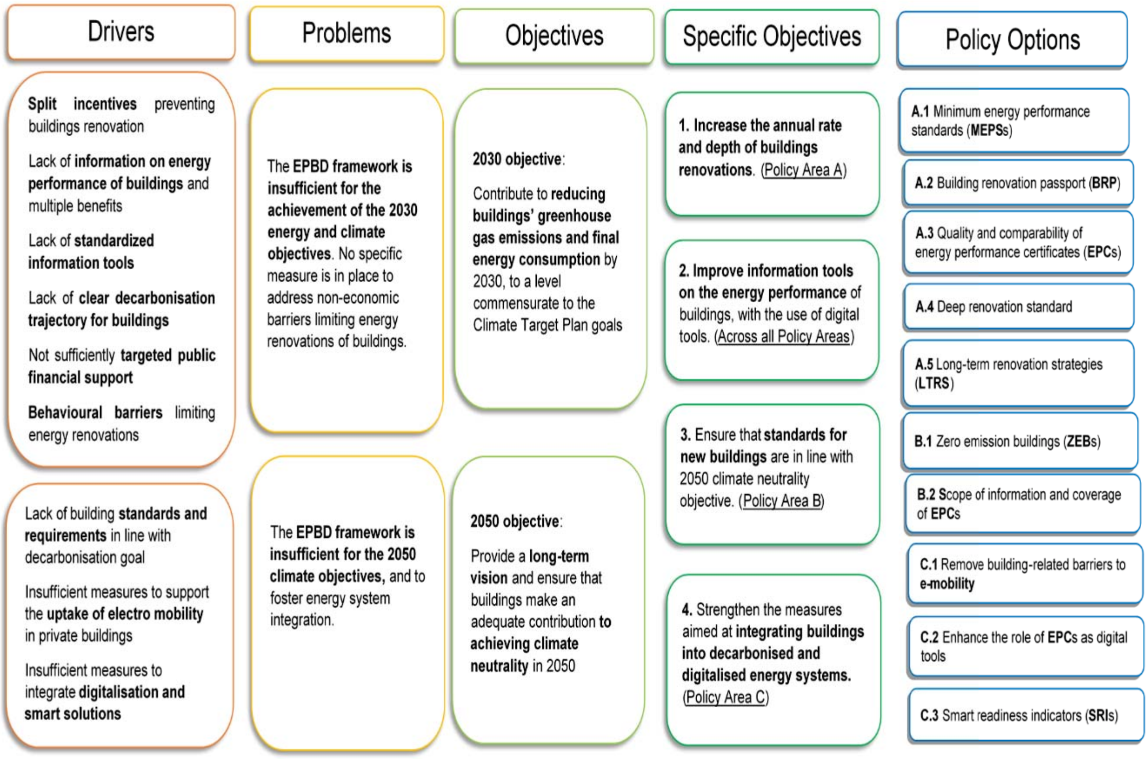
At the same time drivers representing all other DEGD policies are “frozen” on their level of ambition/stringency as modelled in MIX.

In the MIXwoEPBD variant, because of removal of drivers described above, a gap to overall EE and RES ambition appears as well as gap to GHG 55% target. Bridging these gaps can be attributed to revision of EPBD. As this variant achieves the carbon neutrality in 2050, it has to considerably increase the efforts in fuel switch.

Annex E: Intervention logic and common barriers to building renovations

1. Intervention logic

The figure below visualises the intervention logic, linking the drivers, problems, objectives, specific objectives and policy options. The key problems and their drivers are detailed in section 2 (“Problem definition”). The objectives and specific objectives are laid down in section 4 ("Objectives: What is to be achieved?"). The policy options are presented in section 5 ("What are the available policy options?").



2. Common barriers to energy renovations in buildings

The Renovation Wave Strategy Communication addressed the need to significantly increase energy renovations in the European Union, by setting the objective to at least double the annual energy renovation rate of residential and non-residential buildings by 2030.

In the preparation of both the Renovation Wave Communication and the present Impact Assessment for the EPBD revision a number of stakeholder consultations, in-depth literature reviews and targeted studies were undertaken in order to identify the different set of barriers to energy efficiency renovations in EU Member States. Some of these barriers to energy efficiency renovation in buildings are more or less relevant depending on the Member States, and sometimes of regions within Member States. However, albeit with a different weight across Europe, all of these barriers taken together account for the insufficient annual renovation rates in the EU and the existing gap toward the 2030 decarbonisation target for the building sector.

The barriers to energy renovations could be divided in six main categories:

(1) Economic and financial barriers associated to building renovations, from the high upfront costs and affordability of building renovation, to access to finance, to the issue of the split of incentives, and the presence of opportunity and transaction costs and high discount rates;

(2) Behavioural barriers related to consumers support for the uptake of energy renovations, from the lack of knowledge and conflicting information on energy performance of buildings and multiple benefits of energy renovations, to a general lack of acceptance on the need to step-up decarbonisation efforts, including in buildings, until the inertia, the perceived hassle of renovations, and the aversion to indebtedness and financial risk;

(3) Information barriers associated with the lack of accessible, transparent and comparable information across the board and EU Member States on the decarbonisation trajectory for buildings, lack of comparable and standardised informative tools on the energy performance of buildings across the EU, as well as lack of information on available funding opportunity for energy renovation investments and of the potential lower credit risk associated to energy efficiency investments;

(4) Administrative barriers related to both the insufficient technical expertise and capacities among local and regional authorities to support building renovation programmes, length administrative process and permitting procedures;

(5) Technical barriers related to the possible shortage of skilled workforce for energy renovation, lack of standardised practices and industrialised solutions in the building renovation market, as well as lack of internal skills and accessible advisory and quality assurance support for non-professional building owners;

(6) Organisational barriers associated to the complexity of building ownership and use, where co-ownership and collective decisions process are often the norm, and where the commercial lease of buildings and buildings unit add in term of complexity and split incentives between rentees and renters;.

On the top of these six categories of stable barriers, some temporary and periodic barriers might arise that affect energy renovations across EU Member States. These are often of macro-economic nature and related to market cycles, market interventions and market adjustments. In the last two years, a number of consequences that stems of the Covid-19 global pandemic have affected the market of energy renovations. The interruption of the global shipping routes had a cascade effects on the availability of construction materials. At the same time, in EU Member States, the high number of public subsidies for energy renovation released on the market, in particular by the Recovery and Resilience Facility, has generated a temporary shortage of skilled workforce for energy renovations and consequent increase in the costs of renovations. While the demands for energy renovations in building is expected to grow in the next year, these initial shocks are expected to fall back and the market to adjust.

The barriers to buildings renovations are presented in the following table.

Table E.1: Barriers to building renovations

Type of barrier	Barrier
Financial barriers	Upfront costs and affordability of energy renovations
	Weak economic signal
	Split incentives
	Lack of access to public and private financial support for affordable renovations
	Limited public funds, public financial support not sufficiently targeted toward deep renovations
	Lack of clear property value differential
	Transaction costs, high discount rates
Behavioral/consumer barriers	Lack of knowledge, conflicting or lack of information on Energy Performance of buildings and multiple benefits of energy renovations
	Time and hassle factor, inertia
	Perceived risk, attachment to incumbent technologies
	Lack of acceptance of need to step-up decarbonisation efforts, including in buildings
	Aversion to financial risk and indebtedness for energy efficiency investments
Information barriers	Lack of well-communicated decarbonisation trajectory
	Lack of standardized informative tools on energy performance
	Lack of information on available funding opportunities (public and private) for energy renovations on buildings, and on the potential lower credit risks of EE investments
Administrative barriers	Regulatory & planning (e.g. limitation in façade intervention, approval process for renewable installation and renovation permits)
	Lack of technical expertise and capacities in regional and local administration for energy efficiency renovation programmes
	Burdensome administrative processes (multiple permitting procedures, no single entry point)

Technical barriers	Lack of skilled workforce for energy efficiency renovations, lack of low-carbon renovation skills
	Lack of standardized practices and industrialized fast-track solutions for energy renovations in buildings
	Lack of quality assurance for complex renovation
Organisational/Building complexity barriers	Collective decision problems for co-owned properties
	Commercial lease barriers

Economic and financial barriers are one of the main barriers to the uptake of higher renovation rates across Europe. Financial barriers are first and foremost associated with the up-front capital costs and affordability of energy efficiency measures and deployment of renewable energy technologies in buildings. Although the challenges and way to overcome the economic and financial barriers might differ per building types, these barriers are present for both public buildings and private residential and service buildings. Open public and targeted stakeholder consultations, both for the Renovation Wave Communication and EPBD revision, point clearly at the lack of sufficient financial incentives to implement energy renovations as one of the most persistent challenges[71].

There a number of other less visible challenges and barriers hampering the uptake of energy renovations and the growth of building renovation rates. The medium-term payback time of investments on energy renovations, and the perceived limited and complicated access to public financial support and favourable private financial products, are two barriers that if addressed could contribute in limiting the challenges represented by the upfront costs and affordability of energy renovations. Under this light, with regards to residential buildings owned by non-economic actors and private financial products, a stronger reluctance to indebtedness to finance energy renovations should be registered, when compared to economic actors. Although commercial banks and financial institutions are developing in the recent years – due to increased attention to sustainable financing – a number of favourable lending products for energy renovations, the need to access finance and thus borrow money for an energy renovation, even if at favourable conditions, still represents a very relevant barrier. Due to lack of comparable information on energy performance of buildings across EU Member States, and to the lack of a common definition of minimum thresholds for energy renovations to be supported with

[71] In the public consultation to the Renovation Wave, an overwhelming majority of 92% of respondents see lack of or limited resource to finance building renovation as an important barrier to building renovations. In residential buildings in particular, the second most important barrier identified is lack of simple, attractive and easily accessible public incentive measures for renovation. At the same time more than three quarters of the respondents point to lack of information/low awareness of available financing and to cumbersome procedures and/or financial constraints for accessing public financial support. A significant share of respondents pointed also to lack of mainstream of financing products.

public support, public financial support is often not sufficiently targeted on a cost-effective way toward deep renovations and toward low to medium income households.

Additionally, energy efficiency investments are dependent on the risk associated with the investment class. While energy efficiency renovations are more and more recognised as less risky investments compared to similar capital investments, the direct pay-out of the investment might not always be as interesting for the investors than comparable investments. A real estate enterprises might for example prefer to expand its buildings portfolio by investing in another building block, rather than renovating its existing assets.

The issue of split incentives for energy renovation significantly affects the financial case for energy renovation for buildings which are rented or which are under commercial lease, and the possibility to appropriately stimulate interests for energy renovations in such buildings. In the absence of mandatory obligations to building renovations, the issue of split incentives remains probably the most relevant barriers to the uptake of energy renovations in buildings through market measures.

Behavioural barriers to energy renovations refer to inertia or bounded rationality, in presence of which even the investment decision which will generate high economic or wider benefits are not made. These barriers also relate to resistance to change, inertia and risk aversion. On one side, these are linked to the lack of knowledge and conflicting or lack of information on the energy performance of buildings and the multiple benefits of energy renovations. While the attention to the energy performance of building and on the multiple benefits of energy renovations has been growing, there is still not a diffused public acceptance of the need to addressing energy consumptions and GHG emissions in buildings. For long time, and differently from other sectors, such as transports or industry, energy performance of buildings was regarded as an individual interest of the building owner/energy consumer and not as a source of greenhouses gas emissions with impact on the all society.

Information barriers to energy renovations in buildings are closely related to the general lack of accessible, reliable, transparent and comparable information across EU Member States on the energy performance of buildings. Overall, information barriers are summarised in three major areas, lack of well-communicated decarbonisation trajectory involving energy renovation in buildings, lack of standardized informative tools on energy performance and on methodologies across EU Member States, and lack of information on available funding opportunities (public and private) for energy renovations on buildings.

Measurements, evaluation and reporting methods on the energy performance of national building stocks are often decided at national level and loosely aligned across Member States. Overall, this results on a lack of information, and possible mistrust on the multiple benefits of energy efficiency renovation. Building owners and users are often unaware of the associated costs and benefits of an increased building performance.

Linked as well to the technical and organisational/behavioural barriers, there is a fragmented building sector supply chain, where knowledge and understanding of integrated solutions are limited, and competition between the various services (e.g., technology suppliers, builders), as well as the need for consumers to work with each party to obtain advice and solutions, can be time consuming and confuse decision making.

When it comes to private financial support, the lack of information on the potential lower credit risk of energy efficiency investments represents as well an information not sufficiently accessible to individual companies and consumers. The difficulty in retrieving reliable information on the benefits of the energy efficiency renovations and on how to embark on the renovation journey, is probably one the most relevant barrier that might discourage building owners even in presence of attractive public support[72]. In the consultation on the Inception Impact Assessment, NGOs and business stakeholders stressed that public/consumer awareness of the benefits of renovation should increase. They expressed concern about the current lack of understanding and trust in energy savings from renovations.

Administrative barriers represents a relevant set of challenges for the uptake of energy renovations in buildings. Permitting and certification procedures for energy renovations in buildings are often cumbersome, involving a relevant number of administrative and economic actors. The permitting procedure for the renovation works and the certification of the increased energy performances, necessary to access public financial support as well as favourable private financing, are often of competencies of different administrative authorities. Also in this regards, the lack of standardised tools and procedures represent a significant barrier for the uptake of energy renovations.

Technical barriers for energy renovations refers to the barriers present in the construction industry ecosystem, both we regards individual skills and technological solutions available. Construction workforce and professionals not always possess the skills and competencies to interpret technical information or evaluate energy efficiency opportunities and provide adequate solution for energy renovations aiming at increasing energy performance of buildings. The need for adequate skills is further increased with the diffusion of new technologies, requiring a stronger understanding of buildings' infrastructure and skilled workforce. Additionally, construction sector practices and technological solutions are often very much local. While this is positive in terms of local economic growth and jobs, it has a negative impact in term of development of

[72] In the OPC for the Renovation Wave, 80% of respondents pointed to lack of interest in building energy renovation because it does not pay off and rate this a very important barrier to building renovation. This is closely linked to the fact that in the same OPC, in residential buildings, insufficient understanding of energy use and savings is rated as very important barrier by more respondents than any other barrier. In the case of the residential sector, more than three quarters of respondents point to lack of trust or guarantee that renovation will deliver the energy and money savings or other benefits envisaged.

standardised and industrialised fast-track technological solutions. The availability of more standardised and industrialised solutions for energy renovations will increase the uptake of energy renovations by reducing its inherent complexity. However, the lack of standardised informative tools and methodologies to evaluate the energy performance of buildings across EU Member States represents a relevant barriers also in this regard. Finally, with clear cross-cutting links with behavioural barriers and the possible lack of trust on the multiple benefits of energy efficiency renovations, the lack of standardised solutions and the prominence of tailored solutions can lead to a lack of quality assurance for complex renovations. This is also a very relevant barrier related to the access to public financing schemes and energy efficiency lending products that require assurances in term of increase in energy performances.

Organisational barrier refers to the inner complexity of building ownership status. As buildings are immovable goods, any decision affecting them have to face two major barriers. On one side the ownership status of buildings. Buildings are often co-owned properties and legislation often requires formal decision-making processes and agreement among the owners to intervene on the energy renovation of the building. On the other side, buildings and its different units are commercial goods, leased out to assure a profit through a rent on the basis of a formal contract. The commercial nature of buildings can affect energy renovations due to split incentives. In addition, on the basis of the formal contract between owner and tenants energy renovations can be limited because of organisational reasons.

2. Overview of measures and options

Table E.1: Overview of measures and options

Area A. Measures to increase the number of buildings being renovated and renovation depth: Minimum energy performance standards and information tools				
A.1 Minimum energy performance standards (MEPS)				
	Building type	Trigger point and timeline	Metric and instrument	Ambition level
MEPS1	**Worst-performing rented/sold** residential and non-residential buildings	First obligation from 2027, tightened gradually	$kWh/m_2/y$ EPC class	At least EPC class E (or similar) to allow transaction[73], gradually tightened[74]
MEPS2	**All** residential and non-residential buildings	MSs to set up a scheme by 2027	EPC class or other indicator	Gradual transformation towards ZEB till 2050

[73] It could be established that the upgrade of the building could happen within a set time limit after the transaction. In case of sales, the obligation should fall on the buyer.
[74] For instance: E by 2027, D by 2030, C by 2033.

Area A. Measures to increase the number of buildings being renovated and renovation depth: Minimum energy performance standards and information tools				
A.1 Minimum energy performance standards (MEPS)				
	Building type	Trigger point and timeline	Metric and instrument	Ambition level
MEPS3	**Non-residential buildings** above a certain size	MS to set up scheme by 2024, first obligations from 2026, ZEB on average to be achieved by 2045	EPC class or other indicator	Gradual transformation towards ZEB till 2050
MEPS4	**All buildings**	First obligation from 2026	Based on Energy Label class or carbon emission performance	Require that only best in class heating appliances are installed when they are replaced[75]

A.2 Buildings renovation passport (BRP)					
No.	Policy options	Building Type	Timeline	EPBD Article	Remark / Purpose / Condition
BRP1	BRP framework in EPBD, voluntary implementation by MSs	Voluntary impl.	EC to provide framework by 2023	Art. 11	• EC to set up Common General BRP Framework • BRP to address energy performance • Develop delegated act including detailed common template • Explore feasibility to address whole life carbon and resilience
BRP2	BRP framework in EPBD as in BRP1 + mandatory implementation by MSs	*Up to MS,* Voluntary application of BRP	EC to provide framework by 2023, Implementation by 2025	Art. 11 Art. 17 New Art. on MEPS	Possible actions: • information in EPC recommendations section • requirement for public funding • link with MEPS • training (and certification scheme) for building professionals and BRPs experts
BRP3	BRP2+ Mandatory BRP for certain financial incentives	*Up to MS,* Mandatory application of BRP for certain buildings	EC to provide framework by 2023, MS to set up scheme by **2024**	Art. 11 Art. 17 New Art. on MEPS	As in BRP2

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

[75] Where technically feasible.

No.	Policy options	Timeline	Detailed description
EPCQ1	Voluntary measures to increase quality[76] 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 highest and lowest EPC classes (Best EPC class needs to be 2050 compatible) Mandatory quality control measures amongst the following: • Mandatory visits to produce EPC • Minimum % of controlled EPCs (sample)[77] • Automated and targeted control • Quality control to include site-visit • Possible use of metered data as control Reporting obligations
A.4 Deep renovation standard			
No.	Policy options	Timeline	Sub-options
DEEP1	Introduce in the EPBD a definition		• In line with decarbonisation goals, deep renovation defined as a renovation up to a zero-emission building • Inclusion of staged renovation, supported by building renovation passport
DEEP2	DEEP1+ MS to provide a bonus for building renovation complying with the deep renovation standard	MS to implement by 2025	• In line with decarbonisation goals, deep renovation defined as a renovation up to a zero-emission building • Inclusion of staged renovation, supported by building renovation passport • Member States are required to provide a higher level of financial support for building renovation complying with the deep renovation standard than for other building renovation (Article 10 EPBD)
A.5 Long term renovation strategies			

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

No.	Policy options	EPBD Article	Specific measures and sub-options
LTRS1	Shorten update cycle	Art. 2a, Art. 2a Guidance Document	• Next LTRS update 2024; shorten update cycle for LTRS from 10 years[78] to 5 year • Update the GHG target in line higher climate ambition in 2030 and 2050
LTRS2	As in LTRS1+ Introduce monitoring and reporting measures for the EC and MSs	Art. 2a, Art. 2a Guidance Document Governance Regulation	• Introduce a dedicated monitoring and reporting mechanism linked to the existing bi-annual NECP progress reports[79] • EC to monitor overall target achievement (e.g. by aggregating individual MS pledges in LTRS)
LTRS3	As in LTRS2 + Strengthened LTRS requirements	Art. 2a, Art. 2a Guidance Document	• RES: Increase and documentation of renewable share (in line with the revised REDII) and overall decarbonisation of heating and cooling • Clearly link national roadmaps (and the interim 2030 and 2040 milestones) to the 2050 target

Area B. Options to enable decarbonisation of new and existing buildings

B.1 Zero emission buildings

No.	Description	Target	Timeline	Article	Detailed elements
ZEB1	Introduction of a ZEB definition for new and existing buildings; new buildings to comply with ZEB standards (same approach as NZEBs)	All new buildings, or segments	By 2030, *possible different compliance date for certain buildings segments*[80]	Art. 2, Annex I	Specifications: - EPBD to include criteria and qualitative definition (approach as for NZEBs) - MS to set requirements/thresholds on key indicators (e.g. energy needs, GHG, peak load/load match factor)
ZEB2	Introduction of a ZEB definition for new and existing buildings, based on given benchmarks; new buildings to comply with ZEB standards	All new buildings, or segments	As in ZEB1	Art. 2, Annex I	Specifications: - EPBD to include numerical benchmarks on energy performance -
ZEB3	As in ZEB2 + ZEB definition to include also reporting on	All new buildings	As in ZEB1	Art. 2, Annex I	Requirement to report whole life-cycle carbon using LEVEL(s)[81] framework or equivalent indicators

[78] Governance Regulation 2018/1999, Art. 3 NECP.
[79] Governance Regulation 2018/1999, Art. 17 NECP progress reports.
[80] As it was foreseen for NZEBs, public buildings and/or highly frequented non-residential buildings could be required an earlier compliance date that private buildings.
[81] https://ec.europa.eu/environment/topics/circular-economy/levels_en#ecl-inpage-266

	embodied carbon					

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) Major renovation (Art. 7) b) Renovated building elements (Art. 7) c) Technical building system changes (Art. 8) d) Access to public incentive/funding Additional indicators: Mandatory: operational GHG, (energy need), total energy use, RES, energy carrier of heating appliances (y/n, detail on fuels) Voluntary: 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), reference/distance from carbon neutrality 2050 compatibility OR point to BRP instead of recommendations 5 years validity instead of 10 (Art. 12)
EPCSI3	Additional trigger points for issuing EPCs + Increase mandatory indicators and improve recommendations, with less flexibility + Shorter validity for EPCs	MS to implement by 2025	EPCs mandatory for more building categories (as in EPCSI2) 5 years validity instead of 10 (Art. 12) Additional indicators: Mandatory: operational GHG, (energy need), total energy use, RES, energy carrier of heating appliances, whole life carbon (y/n), detail on fuels)IEQ sensors, 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), reference/distance from carbon neutrality 2050 compatibility, peak heat demand, readiness for alternative heating systems OR point to BRP instead of recommendations

Area C. Measures to increase the modernisation and quality of buildings and of their systems, enabled by digitalisation of information tools

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)[82] • 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

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 • Link EPC to building registry/cadastre • Link to digital logbooks

C3. Smart Readiness indicator

No.	Policy action - general	Timeline	Sub-options
SRI1	Link SRI with EPCs and other information tools	Guidance by 2023	a) Support integration of SRI in other tools (e.g. building renovation

[82] 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)

No.	Policy action - general	Timeline	Sub-options
		MS to achieve 2025	passports, building logbooks, etc.). b) Require to integrate at least SRI label in EPC and BRP
SRI2	As in SRI1+ SRI mandatory for large non-residential buildings with an effective rated output for heating systems, or systems for combined space heating and ventilation, or air-conditioning systems, or systems for combined air-conditioning and ventilation, of over 290 kW	MS to set up scheme by 2024, Achieve by 2026	SRI to be linked to ZEB definition and EPC

EUROPEAN
COMMISSION

Brussels, 15.12.2021
SWD(2021) 453 final

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}

EN EN

Table of contents

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/m^2/year) but can also incorporate broader aspects (e.g. climate performance standards (CO_2/m^2/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

---

[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.

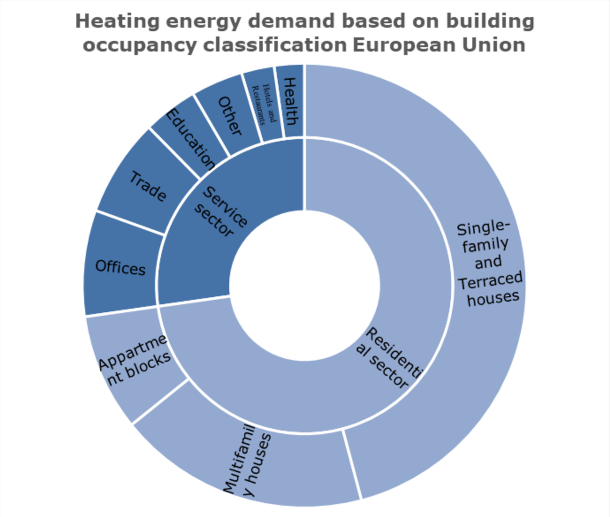
---

[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).

---

[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.

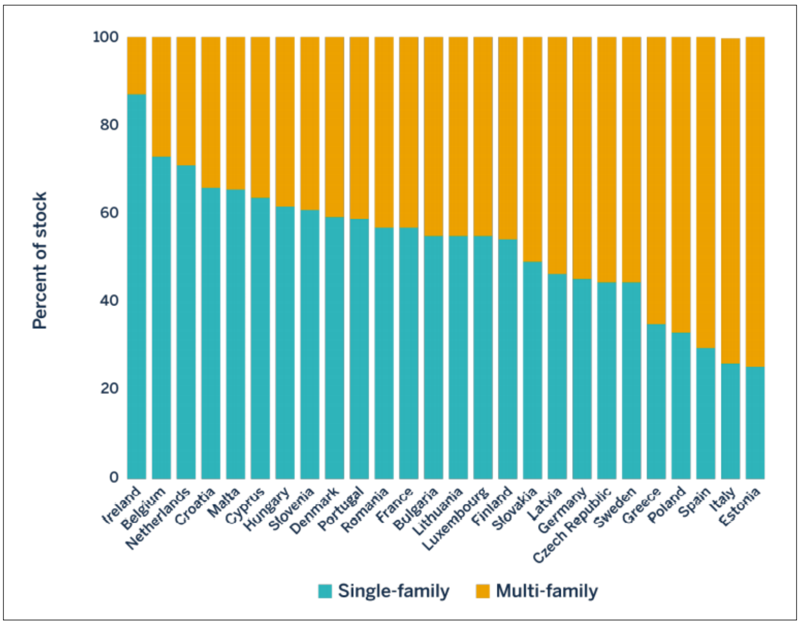
[10] The purpose, governance and frequency of homeowner association varies across the EU and well-functioning homeowners associations is not a given. See for example: Economidou M et al (2018) Energy efficiency upgrades in multi-owner residential buildings - Review of governance and legal issues in 7 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.

[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

[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.

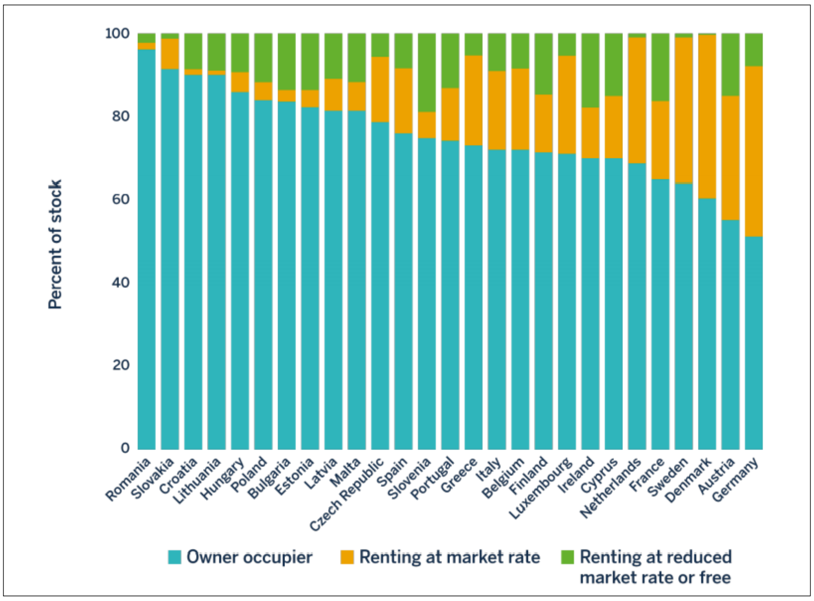
[15] The Pilot Project 'Integrated techniques for the seismic and energy retrofit of buildings' will provide evidence and guidelines for the integrated renovation of existing buildings for energy efficiency and seismic strengthening, based on the analysis of the current state of the building stock in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



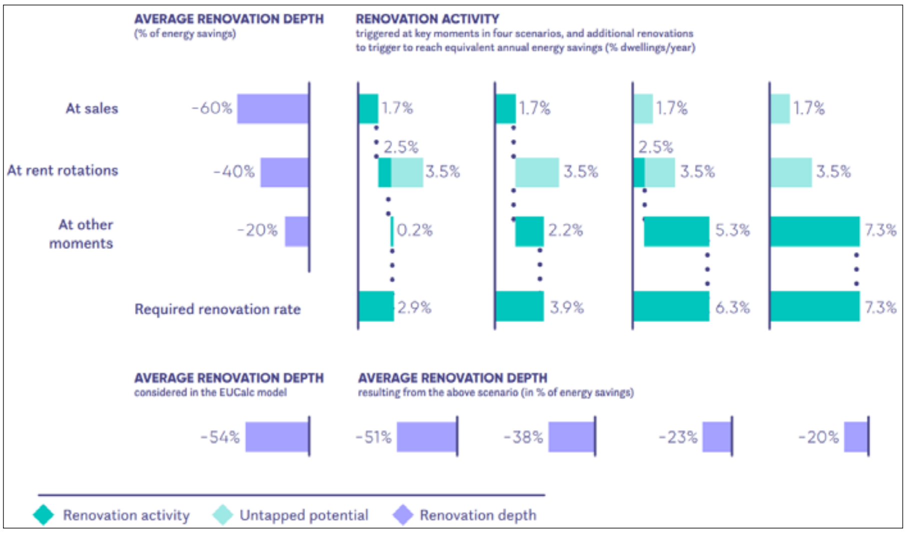
Source: Eurostat/SILC

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

[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 standards22. 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.

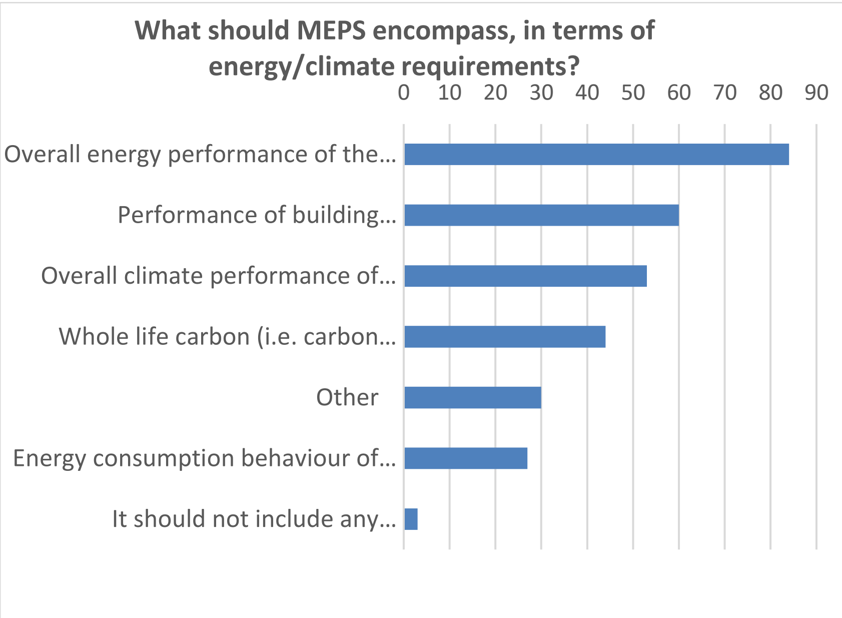
consulted thought that MEPS are a necessary policy for the EU to decarbonise the building stock by 2050. The same share of respondents also argues that the EU should actively support and encourage MEPS.

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)

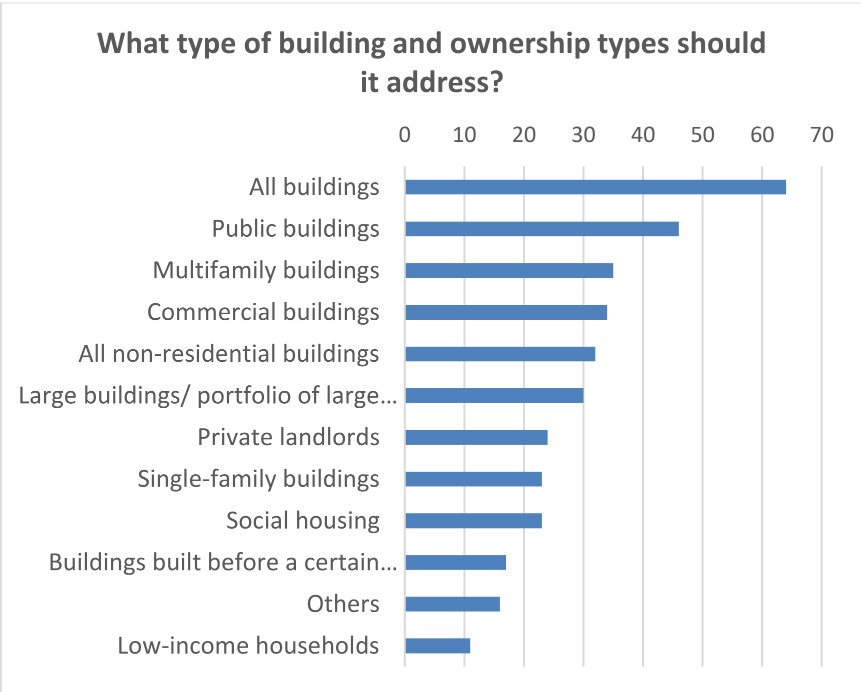


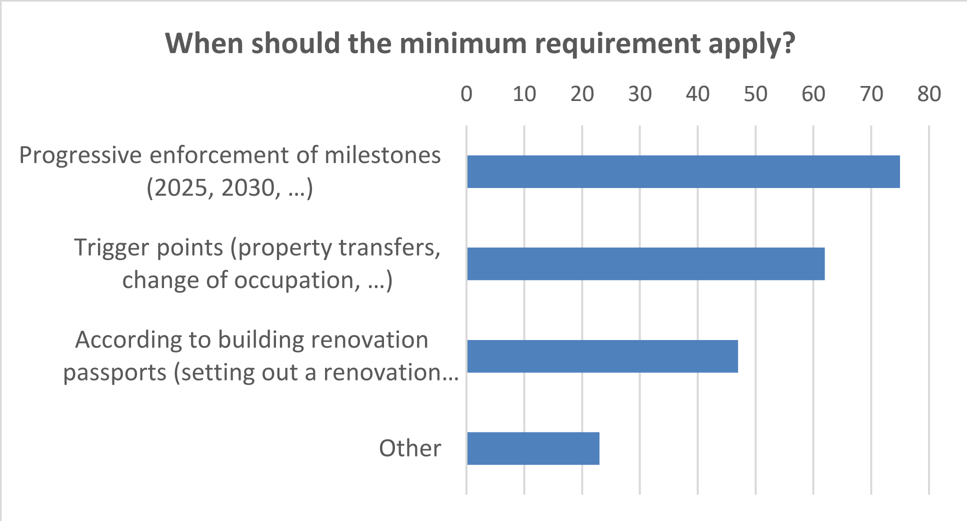
Figure F.6 shows that many stakeholders want the MEPS to include both progressive enforcement of milestones and various trigger points, something reaffirmed in the workshop discussion. In the multiple-choice question on when the MEPS should come into effect, most participants say MEPS enforcement based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

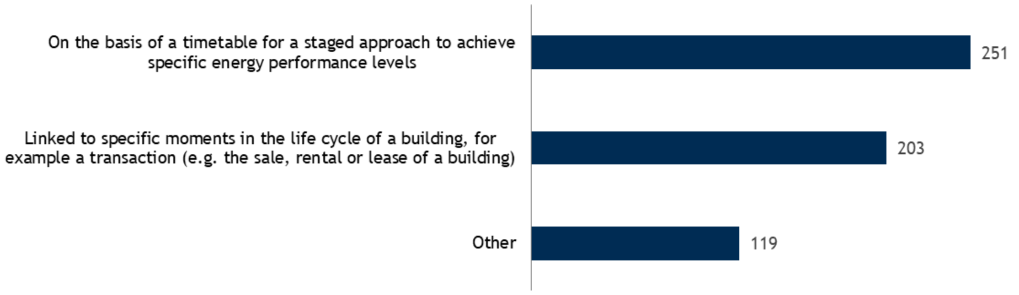
- A detailed planning describing the requirements, which benefits for their application and the timeframe should be developed and revised in a transparent way;
- Minimum of energy efficiency should be fixed (under certain conditions) and take into account the technological evolution of system and materials;
- 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 250m^2 floor space.
- Other publicly owned buildings with floor space larger than 50,000m^2.
- Large privately owned properties with more than 100,000m^2 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 m^2)	2024	Enforcement calendar (compliance cycle of 5 years)
Building performance goals	Reno, Nevada	Residential and non-residential buildings (>2700 m^2)	2026*	Enforcement calendar (compliance cycle of 7 years)
Building Energy Performance Standards	Washington DC	Larger buildings (> 4600 m^2)	2026	Enforcement calendar (compliance cycle of 5 years)
Clean Buildings for Washington Act	Washington state	Larger buildings (> 4600 m^2)	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 m^2)	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 m^2)	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

[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.

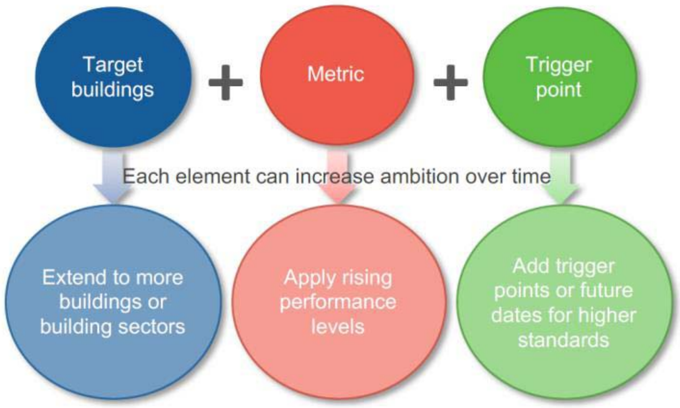
For the identification of options, three main criteria were identified: the target buildings, the metric and the trigger point. As regards the **target buildings**, MEPS can apply to the whole building stock or specific sectors, building types of privately or publicly owned stock. One specific segment 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

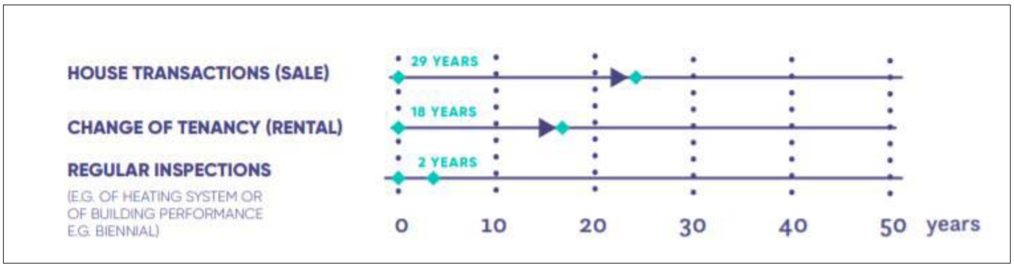
[48] All MS have an EPC framework and a framework for setting minimum energy performance requirements, based on a calculation of cost-optimal levels of energy performance.
[49] Sunderland et al. (2021).

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

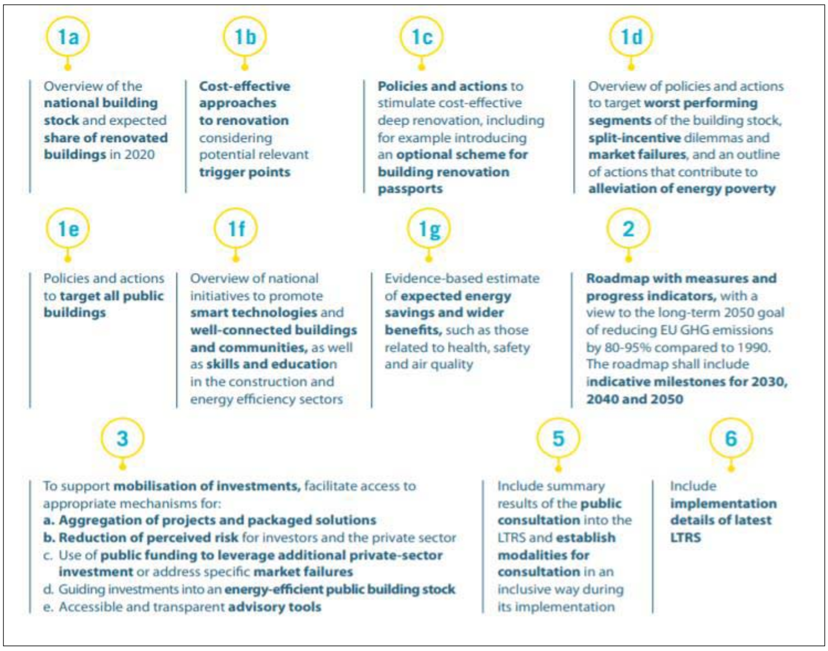
improvement undertaken by home buyers[53]. The MEPS framework should in this case foresee that a certain period of time is allowed to the obligated parties to comply with the obligations, and to do the necessary renovation works which would allow to upgrade the performance to the required level. This 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.

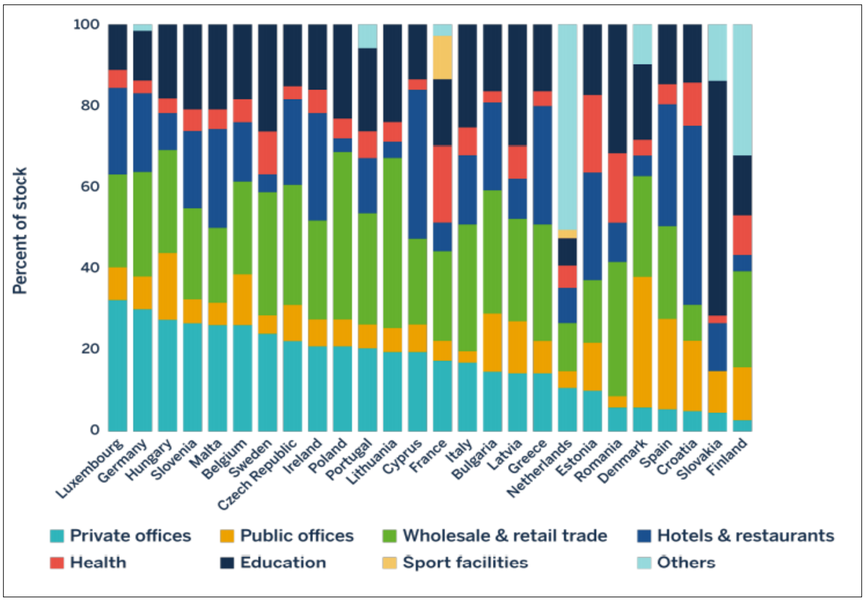


Both options **MEPS2** and **MEPS3** foresee an approach to set standards that relies on criteria and a timeline of implementation and compliance deadlines established in the EPBD, while the level of ambition of the standards and the more specific implementing provisions would be defined at national 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 for other assessment methods (i.e. commercial rating systems) which have different coverage in different countries.

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

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

EPCs are also covered in the following Annexes:

[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

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

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

- 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]

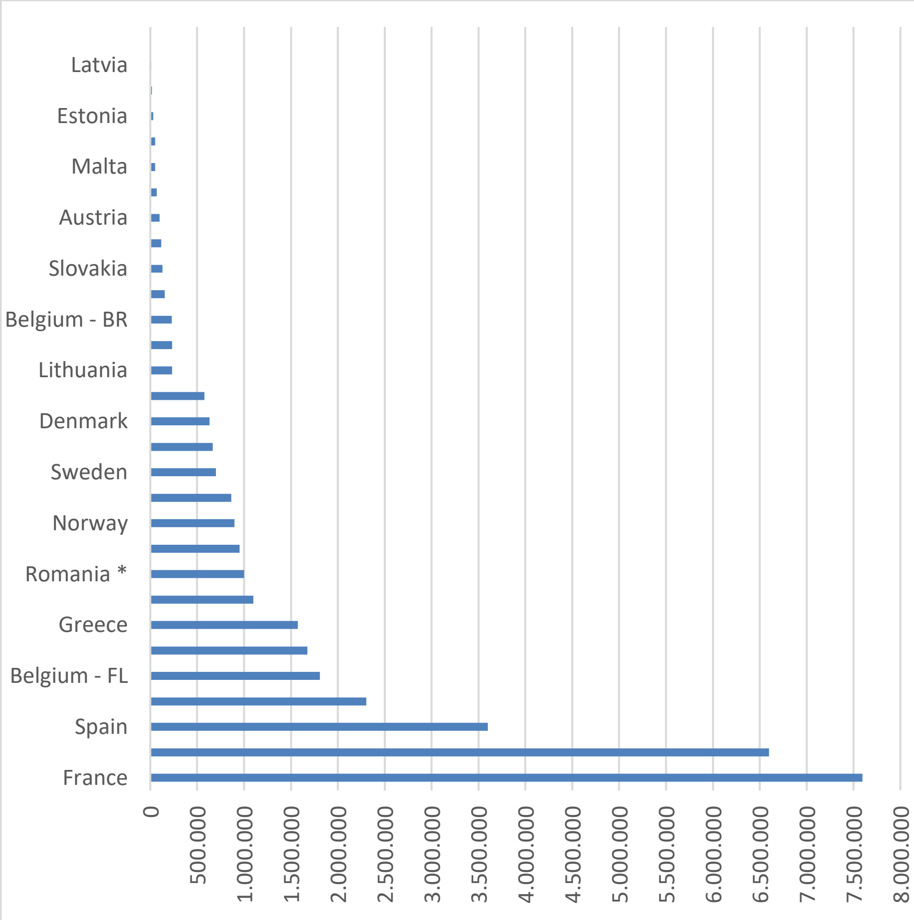
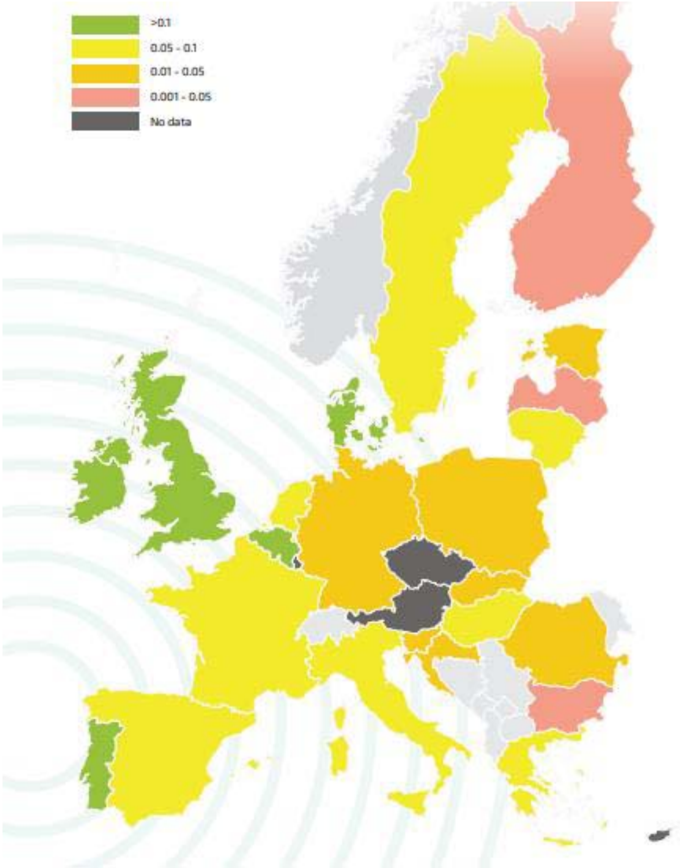


Figure G.2: Total number of registered EPCs per capita in EU and UK [67]

[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	

:

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.

---

[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+1650/A	95+2200/A	135+3200/A	175+4200/A	215+5200/A	265+6500/A	>265+6500/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/m^2)				kWh/m^2			%		
	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.

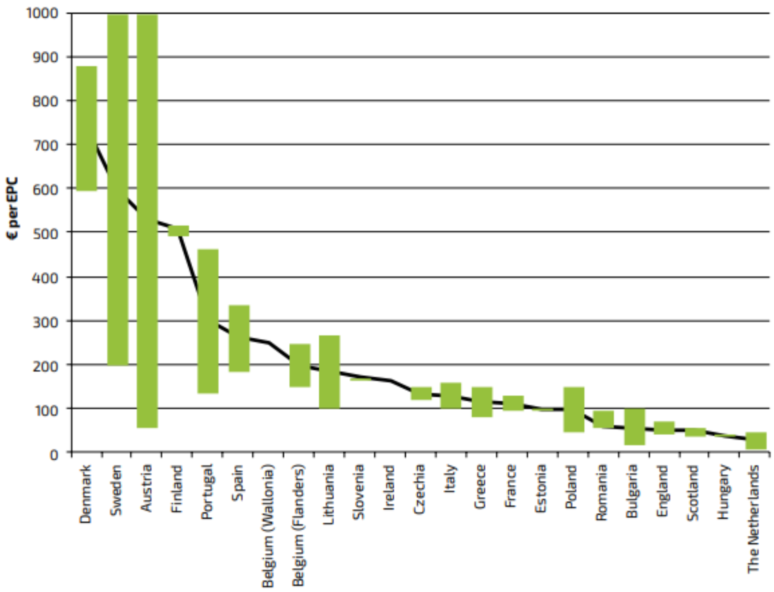
1.6 Cost of EPCs

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]



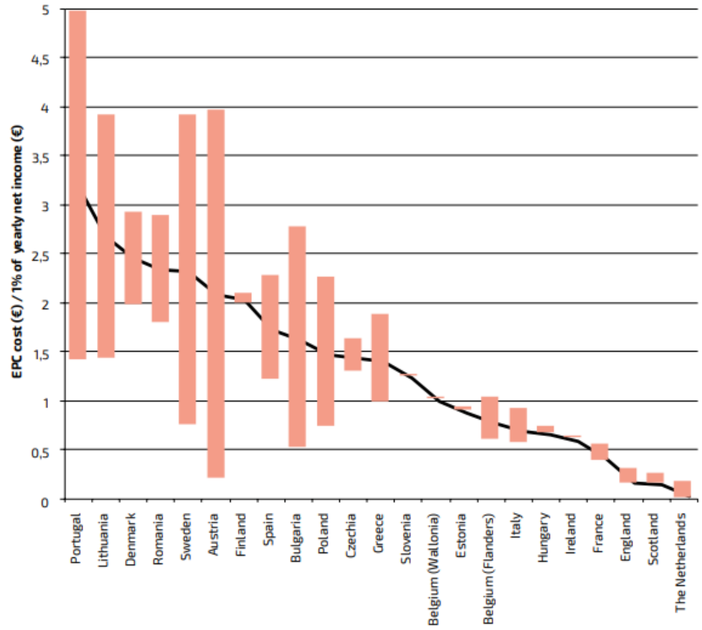
Source: X-Tendo EU project based on own sources and CA EPBD

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

[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
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)

[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/

[93] Modification to Annex II (improve Annex II, include references to targeted mechanisms, but still leave significant flexibility).

No.	Policy options	Timeline	Detailed description
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 certificates”. Several MS have taken this opportunity to improve their building performance methodologies and existing indicators (CA EPBD). Examples of

[94] Increase from “statistically significant” to e.g. 10%.

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

[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.

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

[96] X-tendo project.

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 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)
- 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

[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.

[98] QualDeEPC – High-quality Energy Performance Assessment and Certification in Europe Accelerating Deep Energy Renovation

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**
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	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

[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**
	recommendations, with less flexibility + Shorter validity for EPCs		Additional indicators: Mandatory: operational GHG, total energy use, RES, Voluntary: 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: Mandatory: operational GHG, total energy use, RES, Voluntary:, 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].

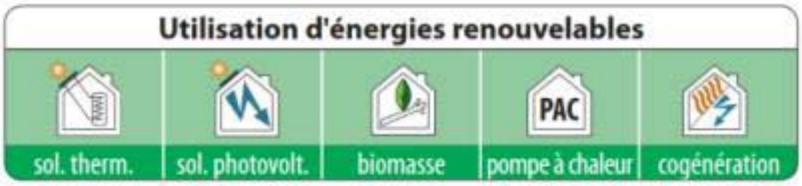
[101] https://doi.org/10.1016/j.rser.2020.110299

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].
- **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

[102] BPIE 2018, Linking indoor environmental quality and energy performance in building regulation.

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 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

[103] SWD(2016) 409 final.
[104] The importance of indoor air quality: ALDREN TAIL | ALDREN

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.

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.

---

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

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 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 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

[106] X-tendo project.

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 • 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

[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.

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 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

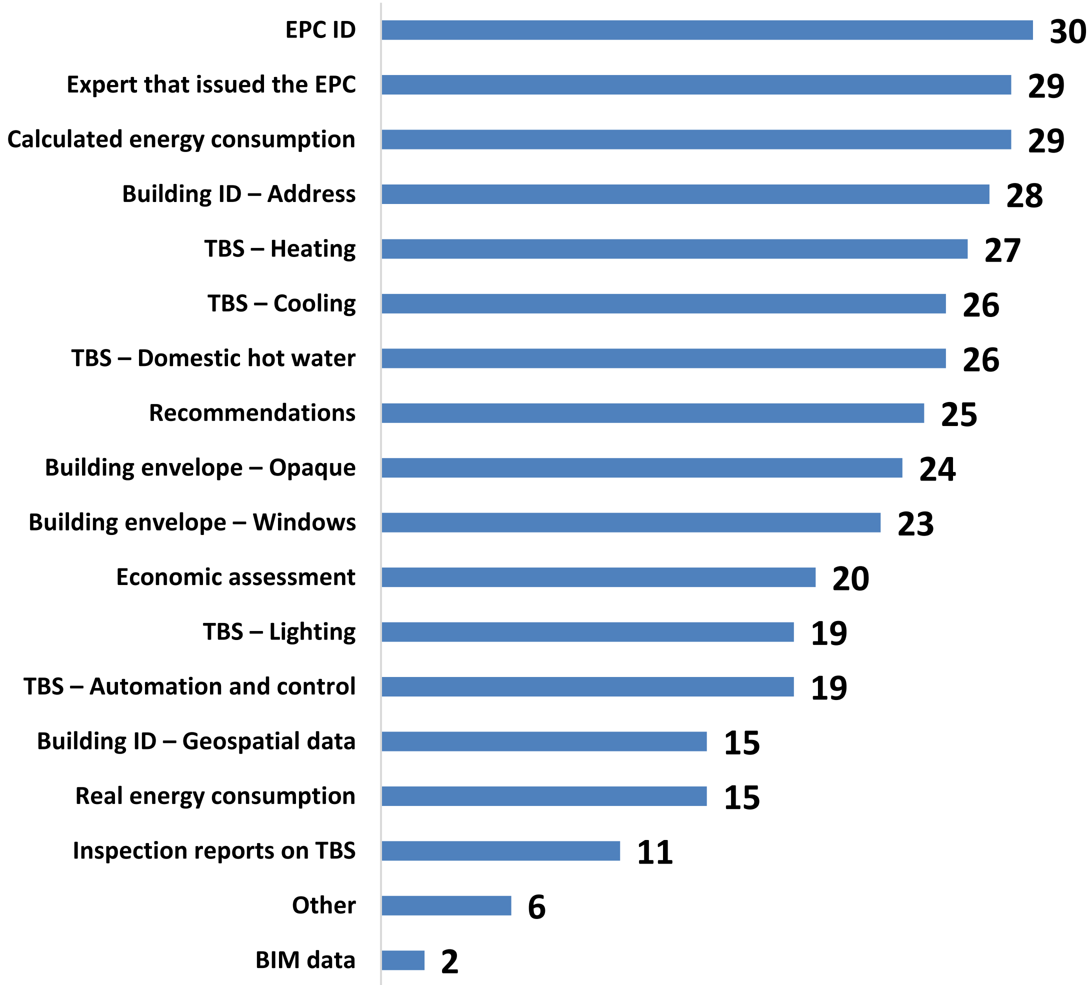
[108] Source: D2_6.pdf; ALDEREN project
[109] https://www.buildup.eu/en/explore/links/request2action-project-6

- 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
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.

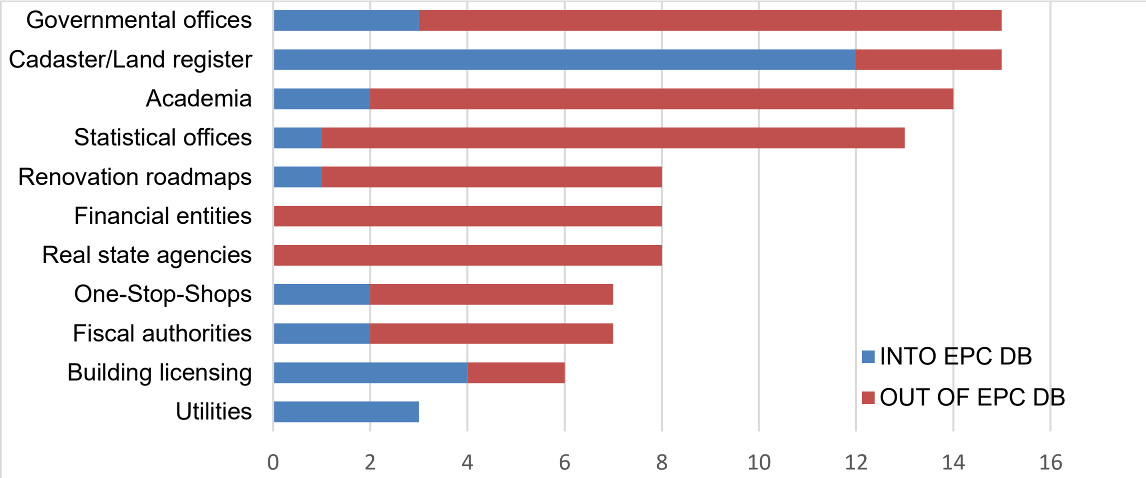
The information from the EPC databases can be shared with other databases. This has the benefit of allowing for the information contained in it to be cross checked. For example, building area can be compared with information in the Land register (to detect errors).

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

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

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).

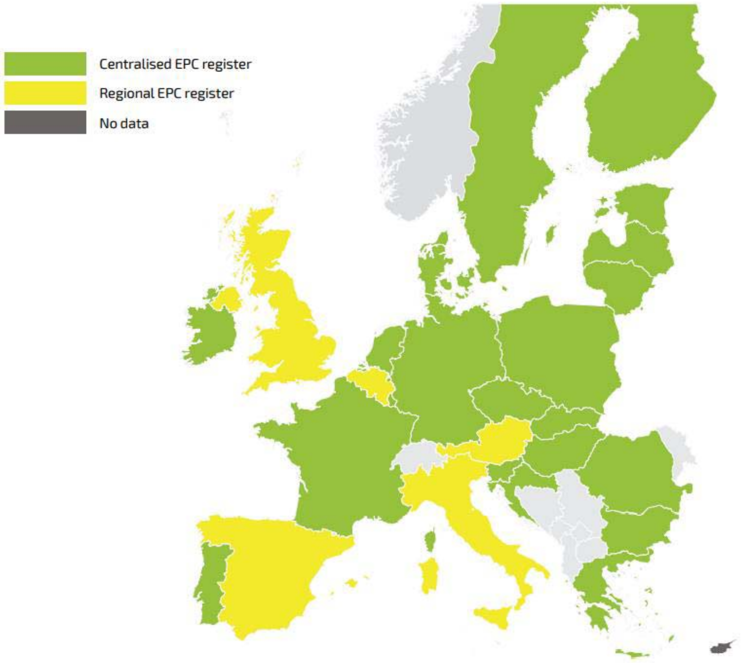
Figure G.8: Interoperability – Type of DB/service connected and main flow of data (in our out) for different MS[112]



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

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



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]

[113] X-tendo project.

	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. 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 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.

[114] BPIE, Lessons learnt study.

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.

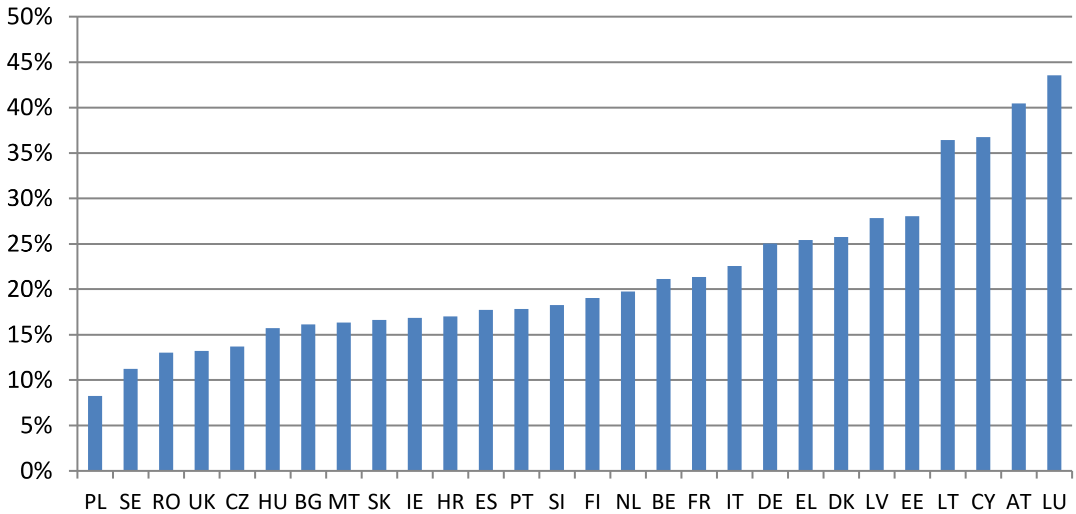
Annex H: Zero Emission Buildings

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]



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).

[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.

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]

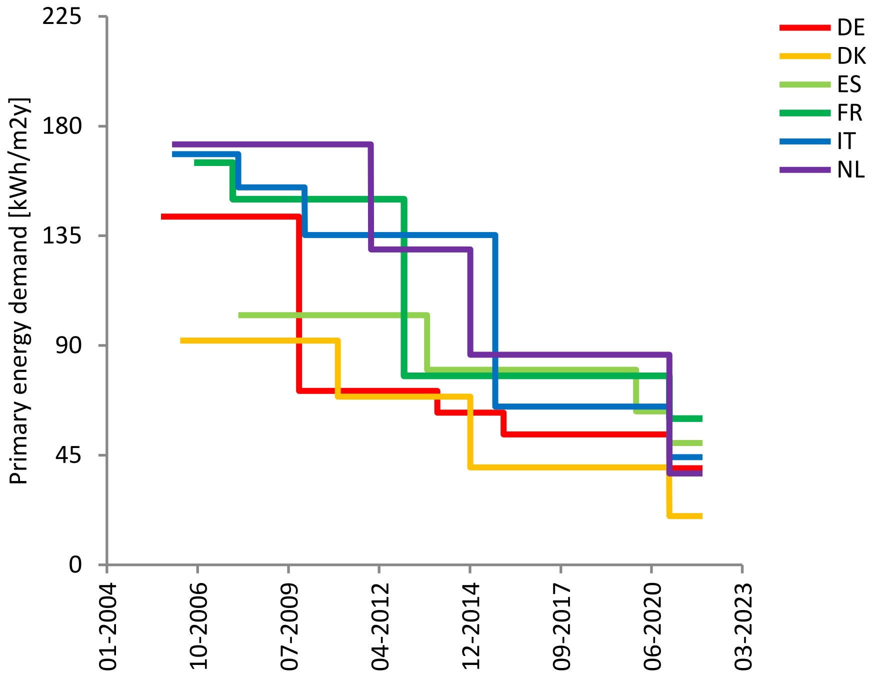
Besides the establishment of technical regulatory measures to define NZEBs, national policies have also been set up in several Member States to stimulate the uptake of NZEBs, through regulatory measures, followed by financial and fiscal measures. Most of the measures target the envelope and heating systems. 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.

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

[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

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 energy performance levels vary from 20 kWh/m^2.y (Belgium Flanders) to 132 kWh/m^2.y

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

(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

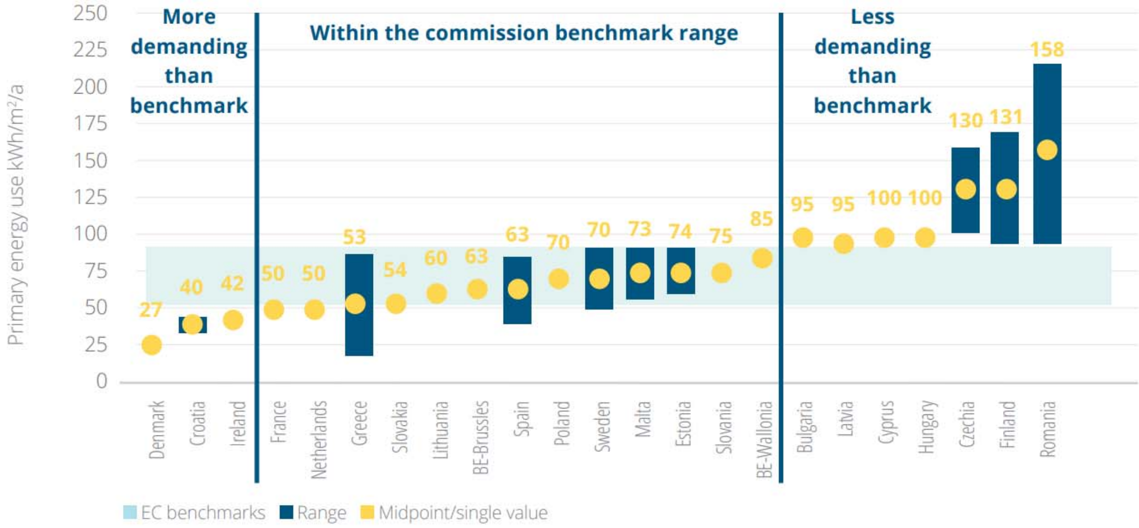
[119] JRC report: Monitoring Member States progress towards Nearly Zero Energy Buildings (NZEBs), under development. To be noted that the figures in many cases are estimated based on assumptions (e.g. averages for different building typologies and climatic zones, calculations based on reference buildings, 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

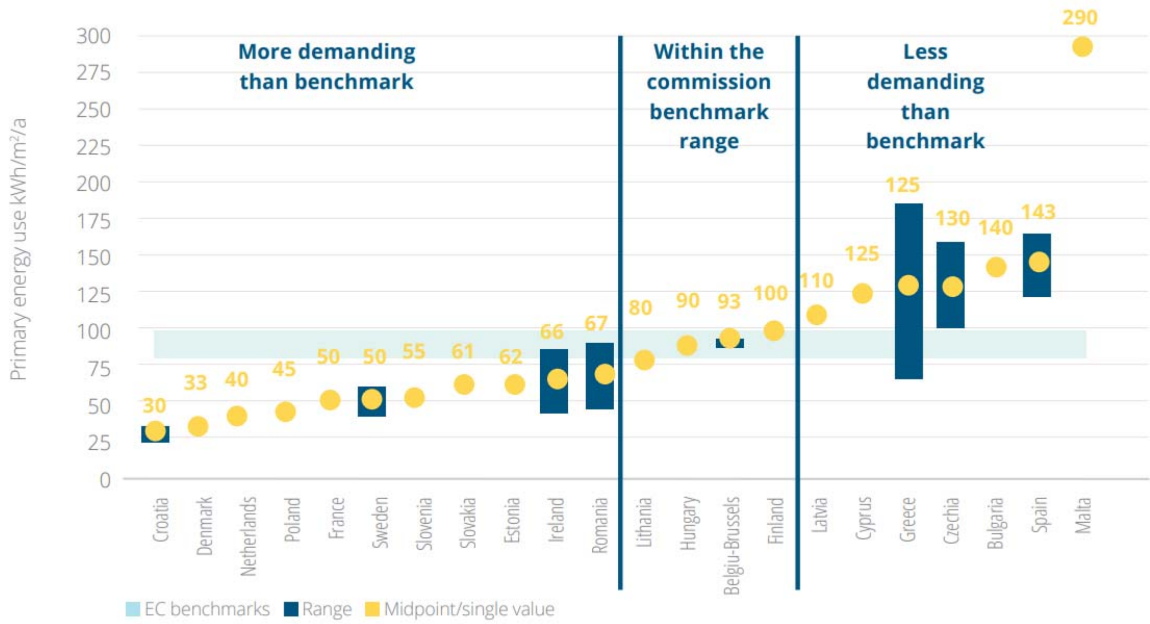
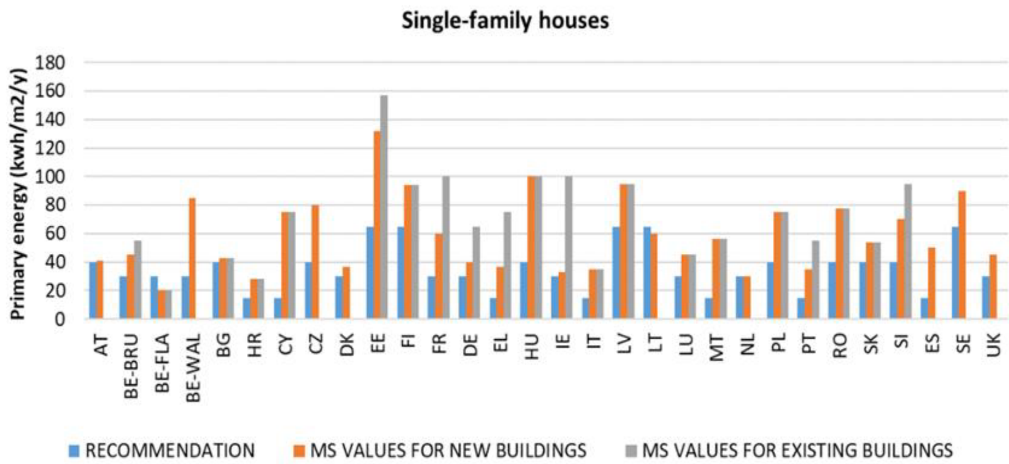


Figure H.4: Indicative comparison of the national NZEB definition for single-family houses and the values in the Commission's Recommendations, JRC[122]



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].

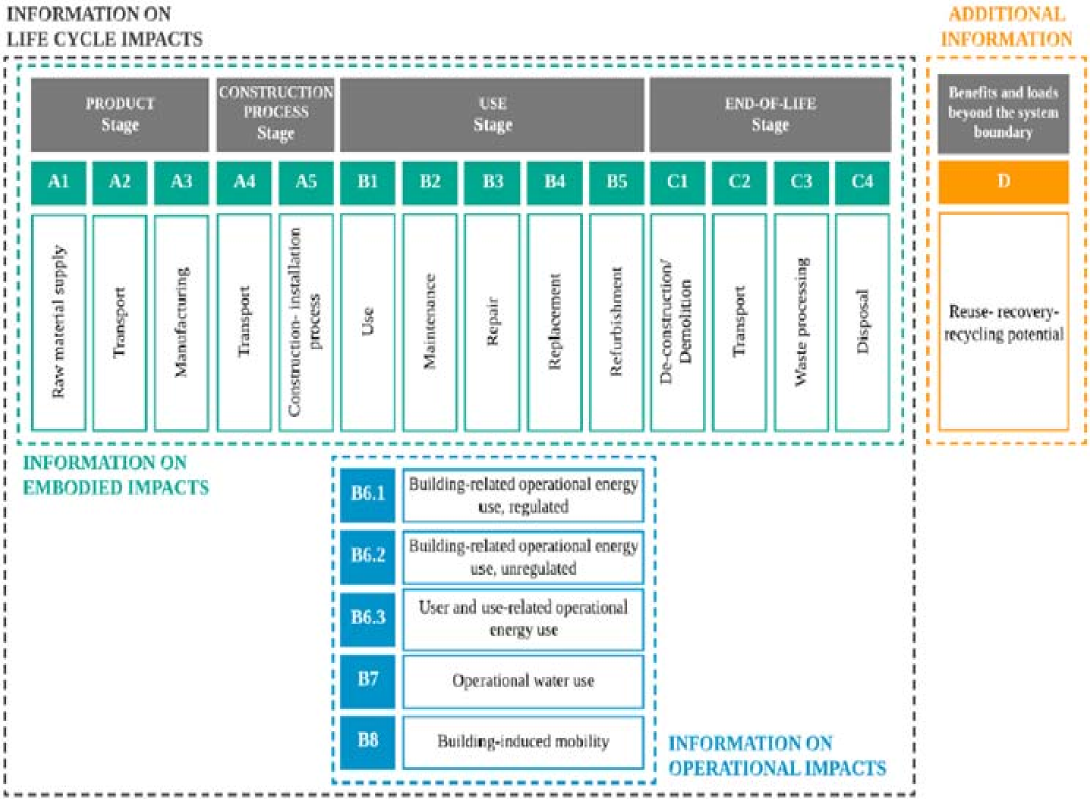
The life cycle emissions consider additionally the greenhouse gas emissions from before and after the operation phase of a building. It includes the extraction and processing of the raw materials, manufacturing of materials and equipment, transport to the site, the construction process of the building, 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 building which could represent additional embodied emissions comparable with those of the construction phase[142].

[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

[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

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].

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):

[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

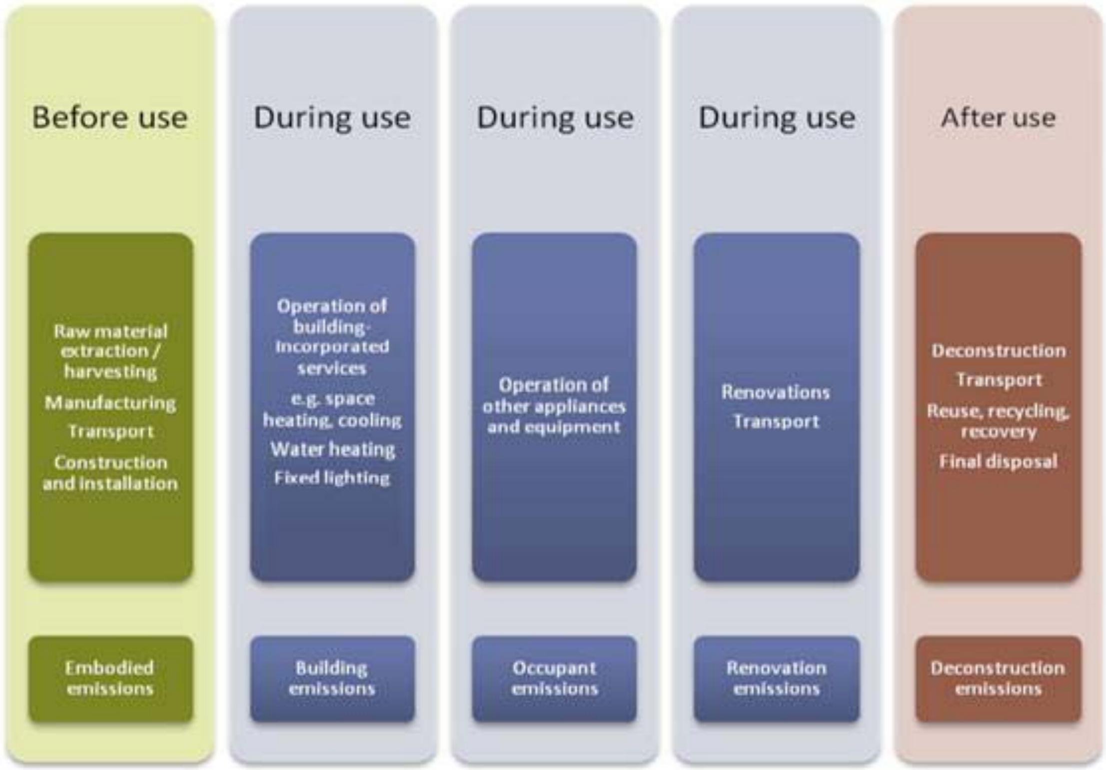
- **Zero carbon building**, which includes the building emissions over the use/operational phase (e.g. Space heating, cooling, etc.)

- **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.

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

[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

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.

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

[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).

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. 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

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

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.

[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.

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".

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	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

	energy scope is calculated and indicated on the energy performance certificates.	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;
- 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

[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

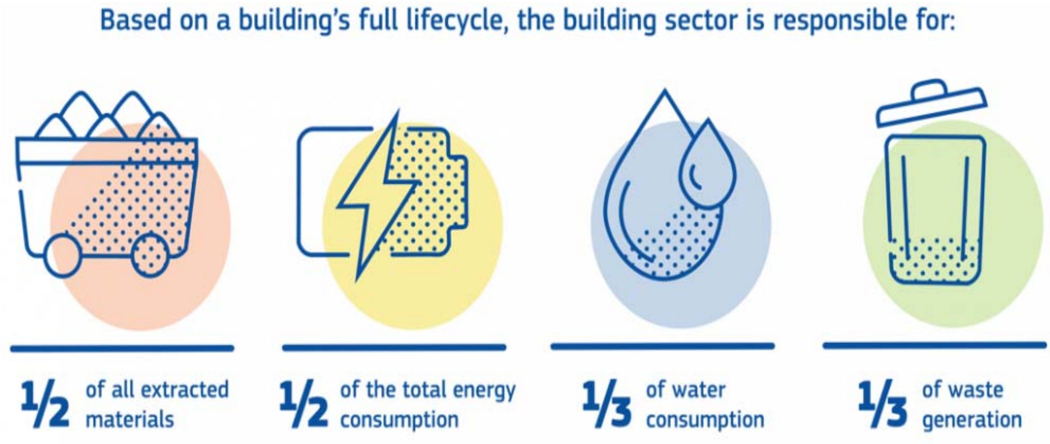
[150] UK Green Buildings Council: Building the Case for Net Zero: A feasibility study into the design, delivery and cost of new net zero carbon buildings, September 2020

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 build high-energy performance buildings with low embodied emissions. An analysis of

[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.*

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 framework for indicator 1.2. Where a national calculation tool exists, or is required for making disclosures

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

---

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

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.

- ETS extension to road transport[180]

[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.

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 re-charging point Ensure the installation of ducting infra-structure for at least 1 in 5 parking spaces
	Residential buildings with more than 10 parking spaces	Ensure the installation of ducting infra-structure 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

[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

<table>
<tr><th>Building type</th><th>Current EPBD</th><th>E-M1</th><th>E-M2 and E-M3</th></tr>
<tr><td>Residential Buildings</td><td>New and major renovation with more than 10 parking spaces[186]:
Ducting infrastructure for every parking space</td><td rowspan="3">All new and major renovation with more than 5 parking spaces:
Precabling</td><td rowspan="3">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)
All non-residential buildings with more than 20 parking spaces:</td></tr>
<tr><td rowspan="2">Non-residential Buildings</td><td>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</td></tr>
<tr><td>All non-residential buildings with more than 20 parking spaces[188]:
by 2025: Minimum number of recharging points to be defined by MS</td></tr>
</table>

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

[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

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)

- 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.

[194] The pre-cabling infrastructure can be assumed at 500 €.

- 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 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.

[195] DECRETO LEGISLATIVO 16 dicembre 2016, n. 257
[196] § 25a i eierseksjonslove and § 5-11 a i borettslagsloven

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:

Strengthening information, legal certainty and incentives for renovation

[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.

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 systems**	2021

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 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.

[205] Based on the analysis underpinning the Climate Target Plan, around 75 % of the GHG emissions are related to energy production and use.

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 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

[206] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.156.01.0026.01.ENG

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 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

[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

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 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.

[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).

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.

---

[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

---

[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/

EUROPEAN
COMMISSION

Brussels, 15.12.2021
SWD(2021) 453 final

PART 4/4

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}

EN EN

Table of contents

Annex L: Administrative costs

1. SCOPE AND INTRODUCTION

The revision of the EPBD includes a set of policy measures covering various aspects of the building sector and buildings renovation. This Annex briefly describes the different measures and analyses the impact of the proposed measures with regards to:

- Enforcement costs and benefits: incurred by public authorities linked to development of legislation, monitoring and enforcement.
- Administrative costs and benefits: incurred when undertaking administrative activities needed to comply with obligations to provide information.
- Indirect costs and benefits: incurred by stakeholders that are not directly targeted by the policy options.
- Compliance costs not directly related to physical renovation of buildings[1].

Direct renovation costs (installation of equipment, architectural works, etc.) and investments are not covered in this annex and are included in Chapter 6.

The acronyms used to identify the policy measures assessed are those indicated and described in Chapter 5 and in Annex E of this impact assessment.

The multiplicity of measures, both proposed and already existing, sometimes results in overlaps that have similar effects in practice. Where relevant, this Annex describes the interlinkages between the different measures and their effects in costs and benefits.

MINIMUM ENERGY PERFORMANCE STANDARDS (MEPS)

MEPS are policy instruments which require buildings to be renovated and improved to meet a specified energy performance standard at a chosen trigger point or date and can include standards that tighten over time. MEPS have an influence on both the rate and depth of renovation.

Effects of MEPS in the private sector

Compliance costs
Compliance costs would consist of renovation costs, which are covered by the general renovation costs indicated by the different policy packages in Chapter 6.

Indirect costs

[1] The costs categories have been defined following as much as possible the indication from Better Regulations.

The introduction of MEPS is likely to have a direct impact in the value of properties and how this value is assessed. Because of this, valuation companies and financial institutions may need to update their procedures and guidelines to account for this changes.

Administrative costs
Administrative costs are related to the need to certify that a building complies with the MEPS.

For policy option MEPS1, when MEPS are linked to sale or rental, the requirement to demonstrate compliance overlaps with the already existing requirement to produce an EPC. Under this scenario:

- If the building owner produces an EPC and the building complies with MEPS, the administrative costs are considered 0 as the obligation to report on MEPS overlaps with the EPC requirement.
- If the building owner produces an EPC and the building does not comply with MEPS, the administrative costs would cover the production of a 2nd EPC following completion of the upgrade works.

For policy options MEPS2 and MEPS3, the costs cover the procurement of an EPC to demonstrate compliance with the MEPS requirements. This would affect only those buildings that do not already have a valid EPC.

Overall, this results in higher administrative costs for MEPS2 when compared to MEPS1, since a number of EPCs under MEPS1 would be covered by existing requirements. MEPS3 costs are lower due to the more limited number of buildings affected. The impact of MEPS4 in terms of administrative costs is considered negligible.

Effects of MEPS in the public sector

Enforcement costs
Public bodies would incur in enforcement costs to cover the development and implementation of legislation, including:

- Assessment studies to define MEPS.
- Update of IT, forms and procedures.
- Development of guidelines and training material (if relevant to national scheme).
- Information campaigns.
- Monitoring and enforcement of MEPS.
- Reporting on developments of MEPS.

Compliance costs
Public bodies would be subject to renovation costs, which are covered by the general renovation costs indicated by the different policy packages in Chapter 6. In the case of public buildings, all public buildings over 250m^2 must already possess an EPC/

Therefore, their performance is already known and there are no additional costs for assessing their performance and determining if a renovation is necessary (i.e. if they are over/under the threshold).

Indirect costs
MEPS would not results in substantive indirect costs for the public sector.

BUILDING RENOVATION PASSPORT (BRP)

Building Renovation Passports provide a clear roadmap for staged renovation over the lifetime of a building, helping owners and investors plan the best timing and scope for interventions.

Effects of BRPs in the private sector

Compliance costs
BRP1 and BRP2 would generate compliance costs only for those building owners that wish to use the scheme. BRP3 would generate compliance costs for those buildings affected by the scheme (e.g. residential buildings and non-residential buildings over 5 000 m^2).

The costs for implementing the measures indicated in the BRP are voluntary and are covered by the general renovation costs indicated by the different policy packages in Chapter 6.

Indirect costs
BRPs would not generate indirect costs.

Administrative costs
The costs of producing a BRP and keeping it updated are covered by compliance costs.

Effects of BRPs in the public sector

Enforcement costs
Public bodies would incur in enforcement costs to cover the development and implementation of the BRP scheme including:

- Development of an EU framework and template (European Commission)
- Development of the national BRP scheme
- Development of guidelines and training material (if relevant to national scheme)
- Monitoring and reporting on the national BRP scheme

Compliance costs
BRPs would generate compliance costs only for those buildings affected by the scheme.

Indirect costs

BRPs would not generate indirect costs.

MEASURES TO IMPROVE QUALITY AND HARMONISATION OF EPCs (EPCQ)

Measures to improve the quality of EPCs, such as defining specific quality levels and methods of analysis as well as reporting mechanisms. Harmonisation measures include, amongst others, the development of a common EU EPC template.

Effects of measures to improve EPC quality in the private sector

Compliance costs
This measure would not result in additional compliance costs.

Indirect costs
This measure would not result in additional indirect costs.

The introduction of additional requirements for EPCs would require the training of existing independent experts. Independent experts already undergo regular training in order to retain their qualifications to produce EPCs. The additional requirement could be integrated in these existing training schemes. Therefore it is considered that the additional requirements would not result in additional costs.

The additional quality measures would also result in increased costs for the management of the EPC scheme. The public administration may or may not decide to pass on these additional costs to the private sector. The increased costs are indicated under enforcement costs.

Administrative costs
This measure would not result in additional administrative costs.

Effects of measures to improve EPC quality in the public sector

Enforcement costs
Public bodies would incur in enforcement costs to cover the following elements:

- Development of a common EU template (European Commission)
- Translation of the template and adaptation of the scheme to the common template (including adaptation of EPC databases)
- Development of guidelines and training material (if relevant to national scheme)
- Increased number and depth of quality controls (manual and automated)

Public bodies would also incur in enforcement costs to carry out the necessary enforcement of the independent control system (quality) for EPCs. The additional cost is calculated on a per analysed EPC basis (i.e. not for all EPCs produced in a year). This would include:

- Update of EPC infrastructure (e.g. calculation engine, database) to adapt to new quality requirements
- Additional automatic controls on EPCs
- Additional manual controls on EPCs (including site visits).

In some Member States, the management of EPC schemes is carried out by private bodies or institutions (e.g. professional associations). These are then in turn under oversight by the public administration. This arrangement does not result in significant differences in costs when compared to the more prevalent arrangement under (full) public administration. In order to simplify the assessment, the IA presents all the costs under enforcement costs.

Compliance costs
This measure would not result in additional compliance costs.

Indirect costs
This measure would not result in additional indirect costs.

INCREASING THE SCOPE, INFORMATION AND COVERAGE OF EPCS (EPCSI)

This sections covers the introduction of additional trigger points to produce an EPC and a number of measures to improve the information aspect of EPC, for example additional indicators and improvement to the mandatory recommendations that must be included in an EPC.

Effects of increasing the scope, information and coverage of EPCs in the private sector

Compliance costs
The additional trigger points for EPCs would result in an increase in the number of EPCs produced and the costs related to it. The additional number of EPCs would depend on the specific definition of the trigger points (in increasing ambition).

Indirect costs
This measure would not result in additional indirect costs.

The introduction of additional requirements for EPCs would require the training of existing independent experts. Independent experts already undergo regular training in order to retain their qualifications to produce EPCs. The additional requirement could be integrated in these existing training schemes. Therefore it is considered that the additional requirements would not result in additional costs.

The additional quality measures would also result in increased costs for the management of the EPC scheme. The public administration may or may not decide to pass on these additional costs to the private sector. The increased costs are indicated under enforcement costs.

Administrative costs
This measure would not result in additional administrative costs.

Effects of increasing the scope, information and coverage of EPCs in the public sector

Enforcement costs
Public bodies would incur in enforcement costs to cover the following elements:

- Development of additional EU guidance (European Commission)
- Transposition by Member States (including adaptation of EPC databases)
- Increased requirements on the EPC scheme (including quality assessment and database)
- Development of guidelines and training material (if relevant to national scheme)

Compliance costs
This measure would not result in additional compliance costs.

Indirect costs
This measure would not result in additional indirect costs.

INTRODUCING MANDATORY NATIONAL EPC DATABASES (EPCD)

This sections covers the introduction of provisions to develop, improve and harmonise databases containing EPCs.

Effects of introducing mandatory national EPC databases in the private sector

Compliance costs
This measure would not result in additional indirect costs.

Indirect costs
This measure would result in overall indirect benefits.

EPC databases would facilitate access to building owners and relevant professionals (e.g. designers, real estate valuators, notaries, researchers) to relevant information, either at the level of individual EPCs or to general information at building stock level. Public reporting and links with other databases (e.g. cadastre) would further facilitate this access while supporting confidence in the scheme.

Administrative costs
This measure would not result in additional administrative costs.

Effects of introducing mandatory national EPC databases in the public sector

Enforcement costs

Public bodies would incur in enforcement costs to cover the following elements:

- Development of additional EU guidance ((European Commission)
- Transposition and implementation of new provisions at MS level
- Adaptation or development of national databases
- Development of guidelines and training material
- Communication and dissemination

Although not a requirement under the EPBD, most MS[2] (except Germany, Italy), already have functioning databases in their territories. Since this is not a current requirement, the costs of running the database are considered a new enforcement cost (even though they are already existing). The new provision on databases would support coherence and harmonisation between databases and would almost certainly require adaptation of the national databases to a certain extent. These adaptation costs are included under the running costs.

EPC databases are an important tool to facilitate the quality assessment process for EPCs. MS already use a number of approaches that exploit the capabilities of a database (e.g. targeting of suspicious EPCs for quality assessment). It is difficult to evaluate the full extent of these benefits. Because of this complexity, the additional benefits are not included in this assessment.

The interconnection between the EPC and other databases would facilitate quality checks. For example, it would be possible to detect differences between the building area in an EPC and the building area in the official cadastre. However, the full extent of this links is difficult to evaluate as there are significant differences between the national databases and how these could be connected and share information with the EPC database. Because of these difficulties, these additional benefits are not included in this assessment.

Compliance costs

This measure would not result in additional compliance costs.

Indirect costs

This measure would not result in additional indirect costs.

[2] Germany has multiple non-centralised databases. Italy has multiple regional EPC databases. Spain has regional databases and is planning a national database (estimated to be online by end of 2021).

DEFINITION OF DEEP RENOVATION (DEEP)

The definition of a 'deep renovation' standard aims to enable anchoring significant private financing to transparent, measurable and genuinely "green" investments.

Effects of definition of DEEP renovation definition in the private sector

Compliance costs
This measure would not result in additional compliance costs.

Additional renovation costs are covered by the general renovation costs indicated by the different policy packages in Chapter 6.

Indirect costs
This measure would not result in additional indirect costs.

Administrative costs
Many financial aid schemes (grants, subsidies, soft loans) require proof of achieving a deep renovation level. In most cases, an EPC or an energy audit report is considered sufficient proof. Compliance with a deep renovation definition would require the same level of proof. Since this would not deviate from existing practice, it is considered that this measure would not result in additional administrative costs.

Effects of definition of DEEP renovation definition in the public sector

Enforcement costs
Public bodies would incur in enforcement costs to cover the following elements:

- Development of a common EU definition for deep renovation ((European Commission)
- Transposition by Member States
- Development of guidelines and training material
- Communication and dissemination.

The concept of Deep renovation is already known and accepted in the building sector. The introduction of a legal definition would only reinforce the existing situation. Therefore, enforcement costs are not considered significant, particularly as in most cases individual elements would be integrated with other measures (e.g. integration of DEEP definition in communication material on MEPS).

Compliance costs
This measure would not result in additional compliance costs.

Indirect costs
This measure would not result in additional indirect costs.

Enhancing Long Term Renovation Strategies (LTRS)

Long Term Renovation Strategies (LTRS) establish a long-term renovation strategy to support the renovation of the national stock of residential and non-residential buildings, both public and private, into a highly energy efficient and decarbonised building stock by 2050, facilitating the cost-effective transformation of existing buildings into nearly zero-energy buildings. The different measures contemplate improvements to the reporting mechanisms and the update and strengthening of some of the requirements.

Effects of enhancing LTRS in the private sector

Compliance costs
This measure would not result in additional compliance costs.

Indirect costs
This measure would not result in additional indirect costs.

Administrative costs
This measure would not result in additional administrative costs.

Effects enhancing LTRS in the public sector

Enforcement costs
Public bodies would incur in enforcement costs to cover the following elements:

- Development of additional EU guidance (European Commission)
- Production of additional LTRS reports (MS)
- Analysis of additional LTRS reports and enhanced monitoring (European Commission

Compliance costs
This measure would not result in additional compliance costs.

Indirect costs
This measure would not result in additional indirect costs.

Introducing a definition for zero-emission buildings (ZEB)

The concept of (net) zero greenhouse gas (GHG)/carbon emission(s) buildings is gaining wide international attention and is considered to be the main pathway for achieving climate neutrality targets in the built environment. As a first step, the impact assessment has the establishment of a sound technical qualitative definition to be introduced in the EPBD, to be applicable to new buildings and based on key criteria which contribute at the same time to achieve high energy efficiency, to limit or neutralise CO2 emission and to contribute to energy system integration" (i.e. addressing flexibility and storage which will be crucial for new constructions). The analysis also examines different timelines to its gradual phase-in and different implementation options.

Effects of introducing ZEB definition in the private sector

Compliance costs
This measure would not result in additional compliance costs.

Additional construction costs are covered by the investment costs for new buildings indicated by the different policy packages in Chapter 6.

Indirect costs
This measure would not result in additional indirect costs.

The introduction of a ZEB definition would require re-training and upskilling of the building workforce (both on-site and off-site) over a period of time. These additional costs would be transferred to the individual building owners through the renovation costs. Therefore, these indirect costs are covered by renovation costs.

Administrative costs
This measure would not result in additional administrative costs.

Effects of introducing ZEB definition in the public sector

Enforcement costs
Public bodies would incur in enforcement costs to cover the following elements:

- Development of a common EU definition for ZEB building (European Commission)
- Transposition of the definition
- Development of guidelines and training material
- Communication and dissemination.

For ZEB3, there would be additional costs related to the introduction of the LEVEL(s) assessment framework or equivalent methodology, which allows for the assessment and reporting on key areas of sustainability in the built environment. The additional costs would include:

- Development and implementation of LEVEL(s) at national level or equivalent methodology
- Development of guidelines and training material
- Communication and dissemination

Compliance costs
There would be no additional compliance costs for the introduction of ZEB1 and ZEB2.

For ZEB3, this measure would result in additional compliance costs related to the production of the LEVEL(s) assessment or equivalent methodology. Any additional costs related to improved renovation are covered by the general renovation costs indicated by the different policy packages in Chapter 6.

Indirect costs
This measure would not result in additional indirect costs.

REMOVING BUILDING-RELATED BARRIERS TO E-MOBILITY (E-M)

The 2018 amendment of the EPBD included a number of measures to support the deployment of charging infrastructure in buildings. Due to the fast development of the electric market, the current revision analysis a number of options to further support this sector and future proof buildings.

Effects of E-mobility provisions in the private sector

Compliance costs
This measure would not result in additional compliance costs.

The capital expenditure of installing the physical infrastructure and charging points in buildings are described in Annex I on e-mobility.

Indirect costs
This measure would not result in additional indirect costs.

Administrative costs
This measure would not result in additional administrative costs.

Effects of E-mobility provisions in the public sector

Enforcement costs
Public bodies would incur in enforcement costs to cover the following elements:

- Development of additional EU guidance (European Commission)
- Transposition and implementation of new provisions at MS level
- Development of guidelines and training material
- Communication and dissemination

Option EM-3 includes additional costs related to the implementation of checks and spot visits. MS could choose to carry out enforcement through the requirement to produce an EPC or an SRI. Under this alternative scenario, the enforcement costs would become administrative costs to be borne by the private sector. It is estimated that the overall costs would be equivalent. For simplicity purposes, the IA only presents the scenario of the checks carried out by public bodies.

Compliance costs

This measure would not result in additional compliance costs.

Indirect costs
This measure would not result in additional indirect costs.

ENHANCING THE ROLE OF THE SMART READINESS INDICATOR (SRI)

The Smart Readiness Indicator, was first introduced in the EPBD in 2018, with the legal instruments adopted in 2020 (Delegated and Implementing Acts). It aims to support the adaption of smart technologies in buildings by measuring how smart ready individual buildings are. The measures in this Impact Assessment cover provisions to improve the links between the SRI and other provisions, and measures to support the adoption of the SRI scheme.

Effects of enhancing SRI provisions in the private sector

Compliance costs
This measure would not result in additional compliance costs.

Indirect costs
This measure would not result in additional indirect costs.

Administrative costs
This measure would not result in additional administrative costs.

Effects of enhancing SRI provisions in the public sector

Enforcement costs
The enforcement costs related to SRI1 are very limited, as it would only require the link between the 2 schemes. For example: EPC to show the SRI value if available, EPC database reporting to include elements from the SRI database.

Enforcement costs for SRI2 include the adoption of the SRI at national level, including the preparation of national legal framework, establishment of a database, development of training material, etc.

Compliance costs
SRI2 would result in the requirement to produce SRIs for public buildings and large non-residential buildings. The analysis assumes buildings over 5000 m^2, which is a similar threshold used in the EU Green Taxonomy for reporting on GHG life-cycle emissions. The size is relevant as any additional costs would be very limited compared to the overall project and construction costs.

The requirements to produce an SRI share many similarities with those required for an EPC (e.g. area or identification of equipment). If both analysis are carried out at the same time, it results in significant savings. In the case of new buildings, an EPC is required in current legislation. Therefore, the analysis assumes that the SRI and the EPC will be produced at the same time, allowing for lower costs.

Indirect costs
This measure would not result in additional indirect costs.

Table L.1: Effects of policy options in the private sector

	Policy Option				Private Sector					
	1	2	3a	3b	Cost type	Description	PRICE (€/unit)	QUANTITY (units/y)	One-off costs (M€)	Annual costs (M€/y)
Introducing Minimum Energy Performance Standards										
MEPS1	x	x	x	x	A	Compliance checks	240	1.200.000		*288*
					I	Update of valuation standards			1	*5*
MEPS2			x	x	A	Preliminary compliance checks	240	2.899.800		*696*
					I	Update of valuation standards			1	5
MEPS3		x			A	Preliminary checks on compliance	240	148.500		36
					I	Update of valuation standards			1	5
MEPS4	x	x		x		Not considered to have significant additional costs.				
Introduction of Building Renovation Passport in the EPBD										
BRP1 (subsidised)	x				A	n° of BRPs triggered	100	69.500		7
BRP1 (unsubsidised)	x				A	n° of BRPs triggered	400	69.500		28
BRP2 (subsidised)		x			A	n° of BRPs triggered	100	139.000		14
BRP2 (unsubsidised)		x			A	n° of BRPs triggered	400	139.000		56
BRP3 (subsidised)			x	x	A	n° of BRPs triggered	100	695.000		70
BRP3 (unsubsidised)			x	x	A	n° of BRPs triggered	400	695.000		278
Enhancing the quality and reliability of EPCs										
EPCQ1	x					*Not considered to have significant costs additional to EPCSI measures.*				
EPCQ2		x				*Not considered to have significant costs additional to EPCSI measures.*				
EPCQ3			x	x		*Not considered to have significant costs additional to EPCSI3.*				
Increasing the scope of information and coverage of EPCs										
EPCSI1	x				A	n° of EPCs triggered	280	3.439.000,00		963
EPCSI2		x			A	n° of EPCs triggered	280	3.719.500		1.041
EPCSI3			x	x	A	n° of res. EPCs triggered	280	4.000.000		1.120
Introducing mandatory national EPCs databases										
EPCD1	x				I	Net person hours saved	30	-8.000		-0,2

	Policy Option				Private Sector					
	1	2	3a	3b	Cost type	Description	PRICE (€/unit)	QUANTITY (units/y)	One-off costs (M€)	Annual costs (M€/y)
EPCD2		x			I	Net person hours saved	30	-10.000		-0,3
EPCD3			x	x	I	Net person hours saved	30	-10.000		-0,3
Introducing a deep renovation standard										
DEEP1	x					*Not considered to have significant additional costs.*				
DEEP2		x	x	x		*Not considered to have significant additional costs.*				
Enhancing the Long-term renovation strategies										
LTRS1	x					*Not considered to have significant additional costs.*				
LTRS2		x				*Not considered to have significant additional costs.*				
LTRS3			x	x		*Not considered to have significant additional costs.*				
Introducing a definition for zero-emission buildings										
ZEB1	x					*Not considered to have significant additional costs.*				
ZEB2		x				*Not considered to have significant additional costs.*				
ZEB3			x	x		*Not considered to have significant additional costs.*				
Removing building-related barriers to e-mobility										
E-M1	x					*Not considered to have significant additional costs.*				
E-M2		x				*Not considered to have significant additional costs.*				
E-M3			x			*Not considered to have significant additional costs.*				
E-M4			x	x		*Not considered to have significant additional costs.*				
Enhancing the role of the Smart Readiness Indicator										
SRI1	x	x				*Not considered to have significant costs additional to those outlined above.*				
SRI2			x	x	E	*Additional costs to produce SRI (on top of EPC)*	50-100	6200-8200		0,31-0,82

Table L.2: Effects of policy options in the public sector

	Policy Option				Public sector							
	1	2	3a	3b	Cost type	UNIT	PRICE (€/unit)	QUANTITY (units)	Lower one-off costs (M€)	Upper one-off costs (M€)	Lower annual costs (M€/y)	Upper annual costs (M€/y)
Introducing Minimum Energy Performance Standards												
MEPS1	x	x	x	x	E	National assessment studies to define MEPS	200.000	27	5,4	5,4		
					E	Update of IT and forms	625.000	27	16,9	16,9		
					E	Setting up Information campaign and training	1.500.000	27	40,5	40,5		
					E	Running information campaign	375.000	81	30,4	30,4		
MEPS2			x	x	E	National assessment studies to define MEPS	200.000	27	5,4	5,4		
					E	Development of national MEPS scheme	500.000	27	13,5	13,5		
					E	Costs of reporting on compliance to EU	25.000	27			0,7	0,7
MEPS3		x			E	National assessment studies to define MEPS	200.000	27	5,4	5,4		
					E	Development of national MEPS scheme	300.000	27	8,1	8,1		
					E	Costs of reporting on compliance to EU	15.000	27			0,4	0,4
MEPS4	x	x		x	E	Implementing best-in-class scheme	200.000	27	5,4	5,4		
Enshrining the Building Renovation Passport in the EPBD												
BRP1 for EC	x				E	BRP schemes in Member States	540.000	9	4,9	4,9		
(subsidised)	x				E	Common EU framework & template (EC)	250k to 500k	1	0,3	0,5		
(unsubsidised)	x				E	BRP schemes in Member States	540.000	9	4,9	4,9		
BRP2 for EC		x			E	Common EU framework & template (EC)	250k to 500k	1	0,3	0,5		
(subsidised)		x			E	BRP schemes in Member States	540.000	27	14,6	14,6		
(unsubsidised)		x			E	BRP schemes in Member States	540.000	27	14,6	14,6		
BRP3			x	x	E	Common EU framework & template (EC)	250k to 500k	1	0,3	0,5		
(subsidised)			x	x	E	BRP schemes in Member States	540.000	27	14,6	14,6		
(unsubsidised)			x	x	E	BRP schemes in Member States	540.000	27	14,6	14,6		
Enhancing the qualifty and reliability of EPCs												

	Policy Option				Public sector							
	1	2	3a	3b	Cost type	UNIT	PRICE (€/unit)	QUANTITY (units)	Lower one-off costs (M€)	Upper one-off costs (M€)	Lower annual costs (M€/y)	Upper annual costs (M€/y)
EPCQ1	x				E	Common EU template (EC)	250k to 500k	9	0,3	0,5		
					E	Translating template to ntl. context & PR	200k to 300k	9	1,8	2,7		
					E	Training and qualification	100.000	9	0,9	0,9		
					E	Increased quality controls					2,3	22,5
EPCQ2		x			E	Common EU template (EC)	250k to 500k	9	0,3	0,5		
					E	Translating template to ntl. context & PR	200k to 300k	9	1,8	2,7		
					E	Training and qualification	100.000	9	0,9	0,9		
					E	Increased quality controls					4,5	45,0
EPCQ3			x	x	E	Common EU template (EC)	250k to 500k	1	0,3	0,5		
					E	Translating template to ntl. context & PR	200k to 300k	27	5,4	8,1		
					E	Training and qualification	100.000	27	2,7	2,7		
					E	Increased quality controls	15 to 150	600.000			9	90
Increasing the scope of information and coverage of EPCs												
EPCSI1	x				E	Developing training and qualification	100.000	27	2,7	2,7		
					E	Implementation by Member States	200.000	27	5,4	5,4		
EPCSI2		x			E	Developing training and qualification	100.000	27	2,7	2,7		
					E	Implementation by Member States	250.000	27	6,8	6,8		
EPCSI3			x	x	E	Developing training and qualification	100.000	27	2,7	2,7		
					E	Implementation by Member States	250.000	27	6,8	6,8		
Introducing mandatory national EPCs databases												
EPCD1	x				E	Running EPC database	150k to 350k	27			4,1	9,5
EPCD2		x			E	Running EPC database	150k to 350k	27			4,1	9,5
					E	Reports to the public	20.000	6,75			0,1	0,1
EPCD3			x	x	E	Running EPC database	150k to 350k	27			4,1	9,5
					E	Reports to the public	20.000	6,75			0,1	0,1
Introducing a deep renovation standard												

	Policy Option 1	2	3a	3b	Cost type	Public sector: UNIT	PRICE (€/unit)	QUANTITY (units)	Lower one-off costs (M€)	Upper one-off costs (M€)	Lower annual costs (M€/y)	Upper annual costs (M€/y)
DEEP1	x					*Not considered to have significant additional costs.*						
DEEP2		x	x	x		*Not considered to have significant additional costs.*						
Enhancing the Long-term renovation strategies												
LTRS1	x				E	Additional LTRS reports	50.000	27	1,4	1,4		
					E	Update EU guidance and check reports	120.000	1	0,12	0,1		
LTRS2		x			E	Additional LTRS reports	100.000	27	2,7	2,7		
					E	Update EU guidance and check reports	300.000	1	0,3	0,3		
LTRS3		x			E	Additional LTRS reports	150.000	27	4,1	4,1		
					E	Update EU guidance and check reports	450.000	1	0,5	0,5		
Introducing a definition for zero-emission buildings												
ZEB1	x				E	EU ZEB framework	50.000	1	0,1	0,1		
					E	Adapting national regulations	100k to 200k	27	2,7	5,4		
ZEB2		x			E	EU ZEB framework	250.000	1	0,3	0,3		
					E	Adapting national regulations	50k to 100k	27	1,4	2,7		
ZEB3			x	x	E	Adapting national regulations	50k to 250k	27	1,4	6,8		
					E	Establishing LEVEL(s) as ntl. framework	50k to 100k	13	0,7	1,3		
					C	Implementing LEVEL(s) for new public buildings	500 to 1.000 EUR	5.000			2,5	5
Removing building-related barriers to e-mobility												
E-M1	x					*Not considered to have significant additional costs.*						
E-M2		x			E	Legal feasibility study & implementation (right to plug)	100.000	27	2,7	2,7		
E-M3			x		E	Legal feasibility study & implementation (right to plug)	100.000	27	2,7	2,7		
E-M4			x	x	E	Legal feasibility study & implementation	150.000	27	4,1	4,1		
					E	Enforcement: site vists / checks	100,00	8k to 20k	0,8	2,0		
Enhancing the role of the Smart Readiness Indicator												

	Policy Option				Public sector							
	1	2	3a	3b	Cost type	UNIT	PRICE (€/unit)	QUANTITY (units)	Lower one-off costs (M€)	Upper one-off costs (M€)	Lower annual costs (M€/y)	Upper annual costs (M€/y)
SRI1	x	x				*Not considered to have significant additional costs*						
SRI2			x	x	*E*	*Setting SRI network*	*200k to 400k*	*27*	*5,4*	10,80	*2,7*	5,40
SRI2			x	x	*C*	*Public buildings SRI assessed*	*50 to 100*	*3500-6400*			*0,18*	0,46

Annex M: The SME Test – Summary of results

<table>
<tr><td colspan="2">(1) Preliminary assessment of businesses likely to be affected</td></tr>
<tr><td><u>The EPBD and SMEs</u>

The EPBD promotes the improvement of the energy performance of buildings and its revision will impact the intensity of activities carried out by SMES. This will happen notably in the buildings construction and related supply chain but also in trade and services sectors, which include industrial sectors, agriculture, machinery and equipment, electricity and gas and heat sector. Most activities in the buildings construction sector are in fact based on small and medium sized enterprises. Up to 95% of construction, architecture, and civil engineering firms are micro-enterprises or small and medium-sized enterprise (SME)[3]. They supply essential technologies, materials and services. Moreover, the built environment is characterized by small and medium enterprises that act locally and provide services in their area. Only companies in the chemicals, rubber and plastic product sector are likely not to be small or medium size.

In 2018, SMEs accounted for 9.3 million jobs in the buildings construction sector of the EU. This represented 86% of total employment in the sector, with 50% micro enterprises, 24.6% for small enterprises and 11.4% for medium-sized enterprises. The SMEs represented almost 100% of the companies active in the in the buildings construction sector of the EU, out of which 94% micro enterprises, 5.3% small enterprises and 0.4% medium enterprises. SMEs generated about 83% of total turnover in the buildings construction sector, out of which 38% from micro enterprises, 28.7% from small enterprises and 16.3% from medium enterprises[4].</td><td>Section 6.4.2 of the Impact Assessment on Macro-economic impacts</td></tr>
<tr><td><u>Specific requirements</u>

The EPBD revision proposes several measures that will trigger, on one hand, an increase renovation rate and depth of the existing building stock and, on other hand, enhanced energy performance for new buildings to be constructed. These measures do not impose requirements specifically to SMEs, but indirectly will have an impact on increasing demand for products and services provided by SMEs in the above mentioned sectors and on installers and inspectors of technical buildings systems in which SMEs represent a substantial majority of employment, turnover and added value.

Among the proposed measures targeting the renovation existing buildings there are minimum energy performance standards, which are policy instruments requiring buildings to be renovated and improved to meet a specified energy performance level. As these requirements apply to building's owners, those will apply also to</td><td>See Section 5.2 of the Impact Assessment describing policy options and Section 8.2 of the Impact Assessment on the preferred option</td></tr>
</table>

[3] https://ec.europa.eu/growth/sectors/construction_en#:%7E:text=The%20construction%20industry%20is%20very,social%2C%20climate%20and%20energy%20challenges

[4] Eurostat, Annual enterprise statistics [sbs_sc_sca_r2]

buildings owned by SMEs falling into the scope of the provisions.	
(2) Consultation with SMEs representatives	
SMEs have been consulted through online public consultation and at five stakeholders consultation workshops on specific topics. 59 SMEs directly replied to the **online public consultation** for the EPBD revision out of which 49% micro enterprises (1-9 employees), 24% small enterprises (10-49 employees) and 27% medium enterprises (50-249 employees). 95% of these SMEs originate from the EU, mainly from Belgium (24%), Germany (12%), and Spain (12%), the rest being from other Member States. Many more replied through business organizations and sectoral organizations, therefore the direct replies from SMEs represent only a limited share of the SMEs consulted. Their replies on main proposed measures for the EPBD revision has been such as in the following: • On **zero emission buildings (ZEB)**: 87% of SMEs considered that ZEB should be defined in the EPBD (i.e. 85% of micro enterprises, 100% of small enterprises and 81% of medium enterprises). 62% small enterprises and 50% of micro enterprises and of medium size enterprises considered that current NZEB requirements are not ambitious enough. 71% of SMEs considered that the definition of NZEB needs to be more harmonized and the introduction of minimum thresholds for primary energy use in the building's operation for different climate zones has been the most popular option. • On **long term renovation strategies (LTRS)**: 54% of the SMEs (mainly micro and medium size enterprises) considered that EPBD provisions on LTRS should not be modified. However, 90% of SMEs considered that the monitoring of the objectives identified by MSs in their LTRS should be strengthened. • On **"deep renovation" definition**: 67% of SMEs considered that it would be beneficial to have a legal definition of 'deep renovation' in the EPBD. • **On minimum energy performance standards (MEPS):** 78% of SMEs considered that the EPBD should introduce mandatory MEPS under specific conditions to be determined, with 83% of them being in favour of mandatory MEPS. The most popular option was for MEPS at building level, mandatory for all residential and non-residential buildings (33 SMEs). • **On energy performance certificates (EPCs):** 71% of SMEs considered that the EPC framework needs to be updated and quality improved, while 82% of them supported their harmonisation with 58% of consulted SMEs in favour of a common template. Regarding the ways to improved the EPC	See Annex B

quality, 69% of the SMEs considered that this can be done by adding further information of estimated costs, energy savings or cost savings, 66% by improving training of independent experts and 64% by including information on non-financial benefits. • **On building renovation passport (BRP):** SMEs suggested that establishing guidelines and best practice exchange are among the main measures to accompany the introduction of BRP schemes through the revised EPBD. • On renovation support schemes: direct grants to low-income households living in worst performing buildings (83% of SMEs) and tax incentives (76% of SMEs) were considered by the responding SMEs as the most important support schemes to renovation. Between April and July 2021, have been organized five thematic workshops[5] supporting the inception impact assessment. The participation of SMEs at these events is summarized in the followings: • ***Workshop 1 – setting a vision for buildings and a decarbonised building stock***: Of the 335 participants, at least 131 participants represented an SME such as: 86 a micro-small enterprise (below 20 employees), 20 a small enterprise, and 25 a medium enterprise. • ***Workshop 2 – minimum energy performance standards for existing buildings*****:** Of the 298 participants, at least 118 participants represented an SME such as:, 73 a micro-small enterprise (below 20 employees), 18 a small enterprise and 27 a medium enterprise. • ***Workshop 5 – accessible and affordable financing – energy poverty*****:** Of the 190 participants, at least 71 participants represented an SME such as: 45 a micro-small enterprise (below 20 employees), 10 a small enterprise and 17 a medium enterprise.	
(3) Measurement of the impact on SMEs	
The analysis in the Impact assessment indicates that the additional economic activities induced by the preferred option for the EPBD revision will generate by 2030 as net effect about 1.8 million additional direct and indirect jobs (out of which 1.4 million low and medium skilled jobs) and EUR billion 104 additional value-added compared to 2020 levels. The effects on employment and valued added are the economic effects that result from increased investments in buildings renovation and reduced energy consumption of fossil fuels for heating. These effects can be considered net effects as they account for simultaneous changes due to investment in renovation and subsequent reduction of energy demand. Most of additional new jobs and value-added will be notably in the construction	Section 6.4.2 of the Impact Assessment on Macro-economic impacts

[5] For two workshops the size of the organisations participating was not collected.

and materials sector (594 thousands jobs and EUR billion 48). It is expected that these impacts will be generated largely by SMEs, which represent more than 90% of the EU companies from buildings construction sector, manufacturing of machinery and equipment and manufacturing of construction materials and glass[6]. Overall, in the preferred option, the number of jobs and value added of the construction and material sector is projected to increase by about 3.6% each as compared to 2020 levels. The proposed measures will also have the effect of reducing energy demand in the sectors that provide fossil fuels for heating, i.e. natural gas, heating oil and coal. It is expected that these negative effects will be limited and will not substantially affect SMEs.	
4) Assess alternative options and mitigating measures	
Delays in the construction sector experienced since the beginning of the pandemic call for an analysis of whether the economy can adapt to higher demand on workforce and skills. Based on the assessment made, the additional demand for labour in the construction sector by 2030 due to the preferred option appears to be smaller (or comparable) to the year-to-year variations in employment between 2008 and 2030. The capacity of the construction market to adapt to higher demand should be supported by the fact that the EU is not at full employment at the aggregate level. The additional demand for labour in the construction sector by 2030 due to the preferred option appears to be smaller (or comparable) to the year-to-year variations in employment between 2008 and 2030. Demand in the construction sector is mostly for unskilled occupations, but pressure in this labour market is mitigated by the decline of unskilled employment in other sectors. Those elements nonetheless have to be considered with care. As showed in the rates of job creation and destruction, the construction sector is particularly cyclical since it depends on business and consumer confidence, but also macroeconomic factors such as interest rates linked to central banks' monetary policies and to governments' budgetary programs. It is therefore not immune to temporary shocks, which may lead to similar delays and temporary price increases as those recorded since the beginning of the pandemic. While those shocks and potential disruptions cannot be fully anticipated, an appropriate package of policies and mechanisms can limit their occurrence and impact. To this end, the Fit for 55 Package overall and the EPBD revision specifically will bring more certainty to a sector that has been facing market and policy volatility in the past. In particular, the price signal stemming from the extended ETS[7],	See Section 6.4.2 of the Impact Assessment on Macro-economic impacts, Section 8.3 of the Impact Assessment on Meeting the challenges of the proposed measures

[6] According to Eurostat structural business statistics 2018 [sbs_sc_con_r2].
[7] Positive anticipation of future carbon costs is among the relevant policy drivers incentivising the choice of energy efficient or low carbon technologies.

regulatory clarity coming from energy efficiency targets under the updated EED and the progressive roll-out of MEPS as well as a higher level of information linked to updated EPCs should incentive the construction sector to expand its capacities. Expanded capacities of both workforce and investments in fixed costs would in turn give more certainty to input suppliers to invest in expanding their own supply capacity. Regarding labour supply, the Renovation Wave Communication acknowledged the 'shortage of qualified workers to carry out sustainable building renovation and construction'. A key challenge is the capacity of the education and vocational training systems to train or re-train workers, as well as to the ability of workers to move from one job and sector to another one requiring potentially different skills[8]. For instance, it is expected that appropriate qualifications will play an increasingly important role in the construction, heating technology and refurbishment sector with new technologies and higher levels of digitalisation. The Commission's initiatives on education, skills and training such as the Pact for Skills, the green strand in Erasmus+ and the Education for Climate Coalition can help to address these challenges. The accompanying Action Plan to the Renovation Wave strategy included a deliverable on "Support[ing] 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"[9]. The proposal for the EED[10] recast also includes provisions for the availability of training programmes and qualification, accreditation and certification schemes as an enabler of energy efficiency improvement measures. In addition, the updated Industrial Strategy of May 2021[11] announced the co-creation of transition pathways for industrial ecosystems, including construction. In a process of co-creation with Member States, industry and other stakeholders, the pathways will identify the scale of the needs, including on upskilling, resource efficiency and digitalisation, and will propose actions to address them. Finally, an increase in productivity in the sector would allow for an expansion of output with less use of labour. Investments in technologies for the industrialisation of construction[12] as well as project management and collaboration tools therefore have the potential to increase productivity and reduce the additional demand for labour. Industrialisation can also result in other benefits including greater resource	

[8] Climate Target Plan Impact Assessment, Part 1, p.86. It is important to acknowledge in this regard that transitional costs such as reskilling and upskilling have not been considered in the simulations of the Fit for 55 Package's impact.
[9] The European Skills Agenda was presented in July 2020 by the Commission. Action 6 is about "Skills to support the twin transitions".
[10]https://eur-lex.europa.eu/resource.html?uri=cellar:a214c850-e574-11eb-a1a5-01aa75ed71a1.0001.02/DOC_1&format=PDF
[11] https://ec.europa.eu/info/sites/default/files/communication-industrial-strategy-update-2020_en.pdf
[12]For example using techniques such as prefabrication and off-site assembly, automation, modularisation and additive manufacturing.

efficiency and less time spent on the building site (and therefore less disruption for building occupants during renovation works)[13]. While acknowledging that not all market frictions stemming from higher demand and new shocks can be tempered, the combination of the proposed policies and initiatives should help to substantially address them.	

[13] D'Oca et al 2018. Technical, Financial, and Social Barriers and Challenges in Deep Building Renovation. Available at https://www.mdpi.com/2075-5309/8/12/174

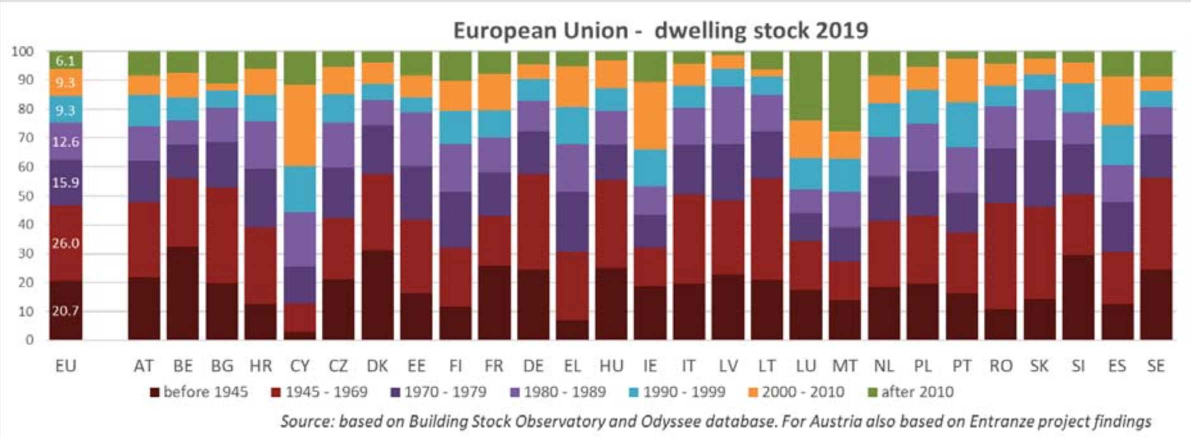
Annex N: The EU building stock

To better understand the barriers to energy renovations across the EU it is important to focus on the European building stock, the basic technical and energy performance features, population distribution and ownership structure.

Before defining the problem, we should focus on the European building stock across Member States, the basic technical and energy performance features, population distribution and ownership structure.

The residential and services (non-residential) sectors in the EU amount to some 25 billion m^2, with the former representing around 75% of the total. Of the current residential building stock, 80% was built before the 1990s, with 40% built before the 1960s (Figure N.1)[14]. The old age of buildings is a common problem across Member States.

Figure N.1: EU dwelling stock per age, 2019[15]



Space heating accounts for two thirds of energy consumption in residential buildings. Space heating and water heating together represent around 80% of the energy consumption of residential buildings in the EU (Figure N.3). This is a common trend across all EU countries; only in four countries in the Mediterranean region heating is below 50% (ES, CY, MT, PT). The energy performance of buildings is however a concept that applies both to heating and cooling. Well-insulated buildings allow for more thermal comfort and lower energy consumption for both heating and cooling.

Around 75% of buildings in the EU are energy inefficient according to current standards. They were built before the introduction of energy performance requirements, which were

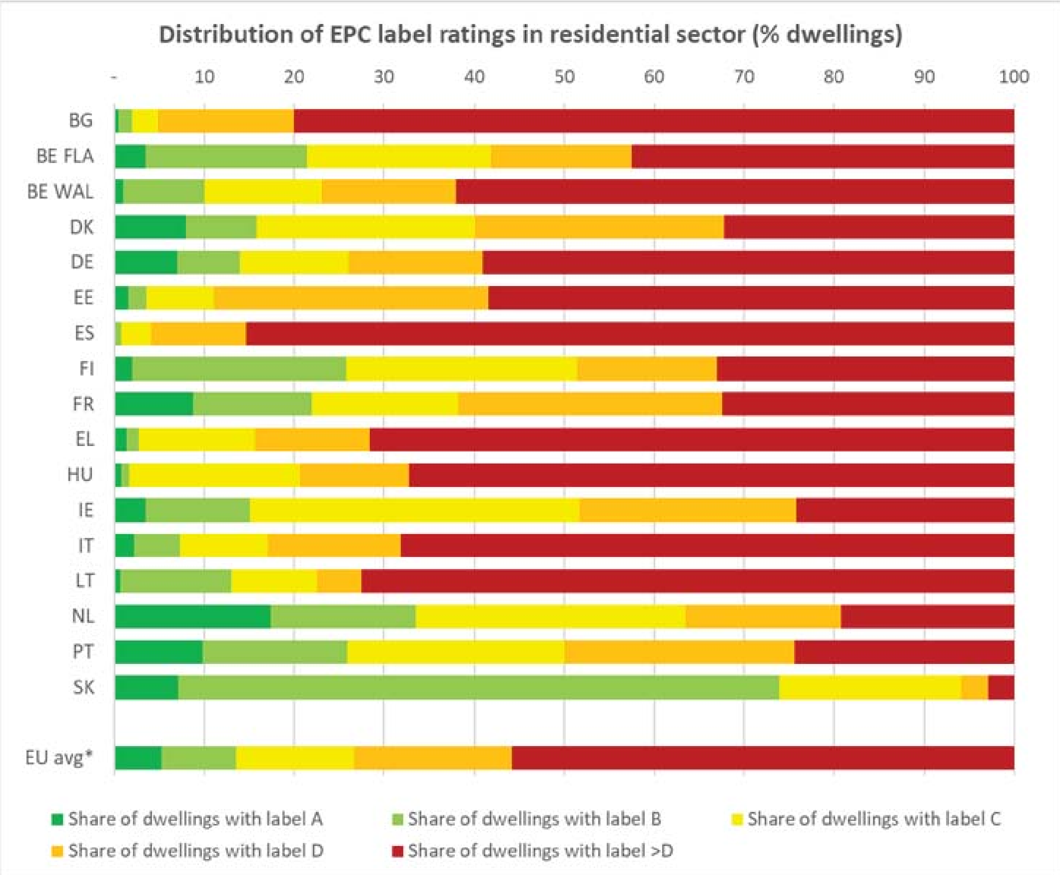
[14] A considerable amount is even older and often classified as cultural heritage. Old building stock would not fulfil state-of-the-art requirements on fire safety and seismic resistance (e.g. likely not to be compliant with Eurocodes standards).
[15] Based on Buildings Stock Observatory and Odyssee database.

first introduced towards the end of the 1970s[16]. Accessibility for people with disabilities was also not included as a general rule in the design of those buildings, and a large number of old buildings do not fulfil state-of-the-art requirements on fire safety, seismic resistance, and indoor quality and daylighting. Although these aspects are outside the scope of the EPBD, renovation of the older segment of the building stock increases the opportunities for broader improvements and integrated building renovations, addressing multiple objectives at the same time.

Longevity is a characteristic of buildings. They typically last a minimum of 50 years. Due to this, it is estimated that 85-95% of the buildings that exist today will still be standing in 2050.

The figures below provide the energy efficiency rating or energy 'class' of buildings, as attributed by energy performance certificates (EPCs)[17] for residential buildings in a number of EU countries.

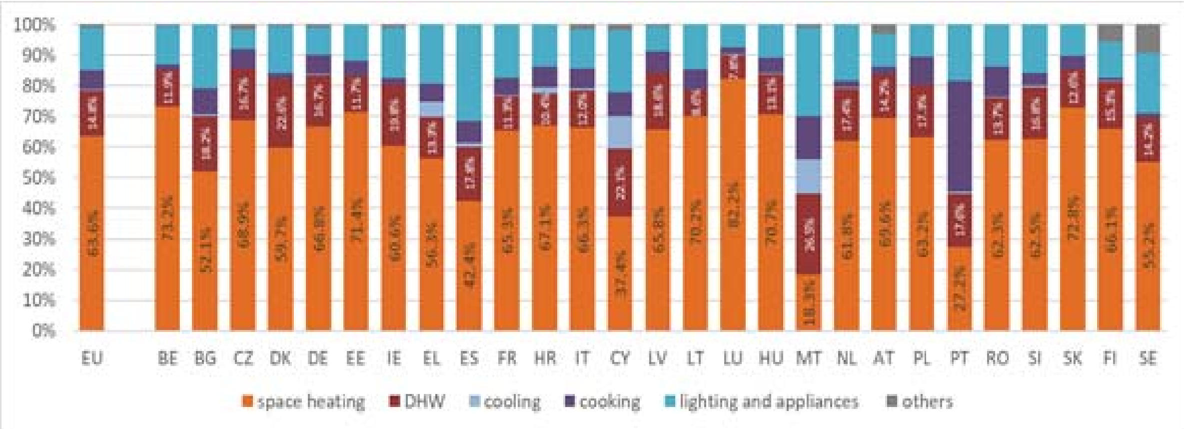
Figure N.2: Distribution of EPC label ratings in selected residential buildings in the EU[18]



[16] JRC (2019), 'Achieving the cost-effective energy transformation of Europe's buildings', cost_optimal_energy_renovations_online.pdf
[17] Annex G explains how EPCs are used.
[18] Adapted from X-TENDO project final report. The figure covers only the Member States for which data was available.

Although several differences exist in the overall performance levels of buildings and classes, the general assumption is that the vast majority of buildings are not ‘fit for 55’, or in any case are not expected to be climate-neutral by 2050. Buildings in EPC class A (‘A label’, green), represent a negligible share of the stock, above 5% in only five Member States. To increase energy efficiency and contribute to decarbonisation by 2030 and in the longer term, a significant share of the building stock should progressively shift to the highest classes. The greatest gains will be achieved from the lowest energy class buildings (D or below), which in almost all the countries examined constitute between 50% and almost 100% of the stock.

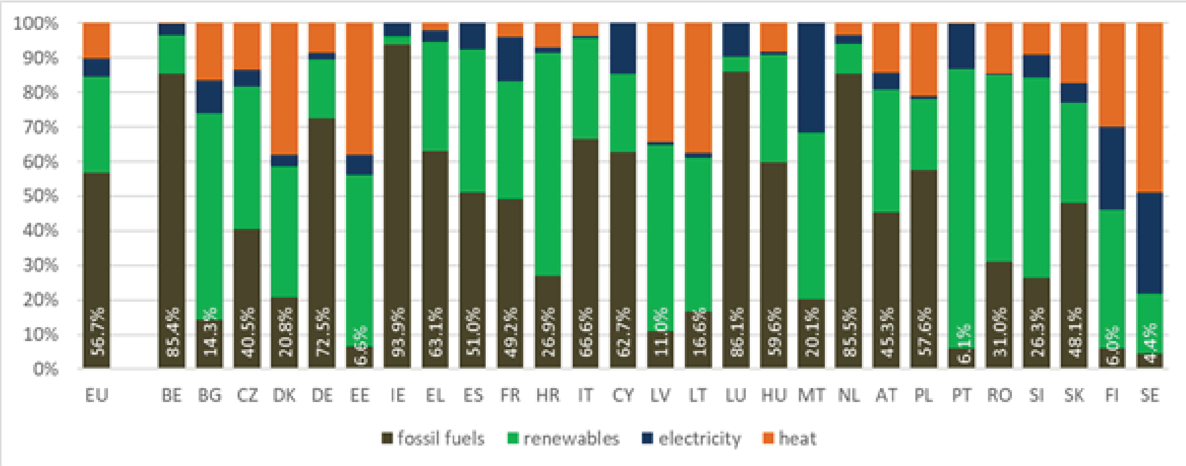
Figure N.3: Final energy consumption of households by end-use type, 2019[19]



Almost 57% of the energy use for space heating in the EU residential sector is based on the direct use of fossil fuels, 10% on district heating, 5.3% on electricity and 28% on on-site renewable energy (Figure N.4). The challenge of decarbonising heating and cooling is therefore substantial in all Member States. Although fossil fuels dominate space heating in countries such as Belgium, Germany, Ireland, Luxembourg and the Netherlands with more than 70% of the heating mix, renewable energy sources cover more than 50% of the energy needs for space heating in Bulgaria, Croatia, Latvia, Lithuania, Portugal, Romania and Slovenia. Solid biomass represents more than 86% of renewable energy used for space heating in the EU, which is largely dominant at individual Member State levels. District heating supplies more than a third of space heating energy in countries with cold climates such as Denmark, Estonia, Latvia, Lithuania, Finland and Sweden.

[19] Source: Eurostat.

Figure N.4: Energy mix of space heating in households, 2019[20]



The GHG emission intensities of energy-related use in EU residential and non-residential buildings is around 166g CO_2 eq (kWh/yr) and 196g CO_2 eq (kWh/yr) respectively (Figure N.5). Emission intensities vary largely across the Member States according to the mix of the direct fuels used. They are lower in countries with a higher use of renewables or where the emissions are attributed to the power and heat sector by making greater use of district heating and electricity.

Figure N.5: GHG emission intensity of direct consumption of fuels in residential and services buildings[21]

An important characteristic of building use that determines the possible obstacles to renovating buildings is related to the building type, ownership structure, and the pattern of building occupancy. At EU level, the distribution of population by type of dwelling is slightly higher for houses (53%) than for flats from multi-family buildings (Figure N.6).

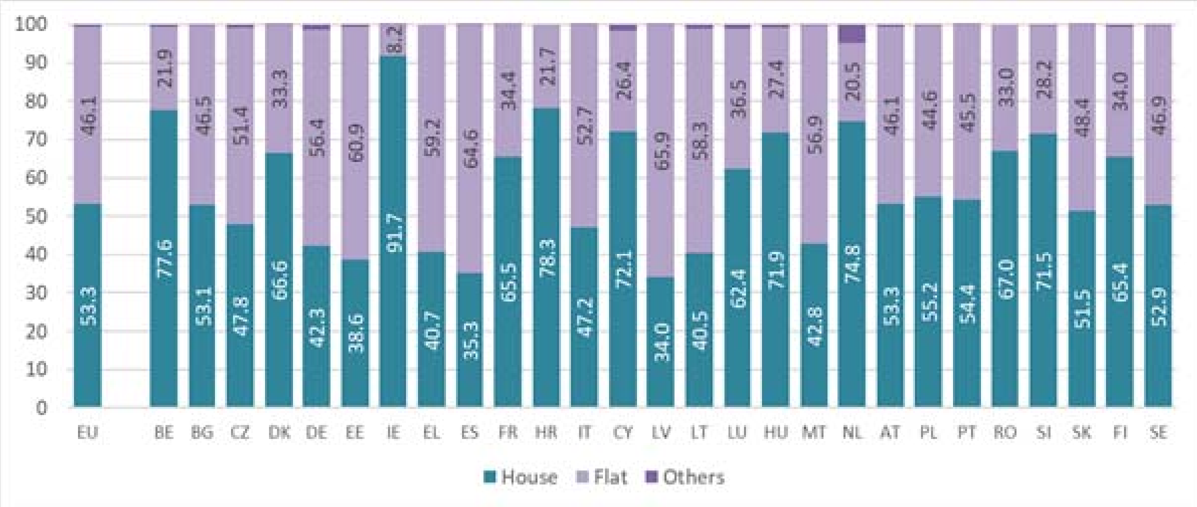
---

[20] Source: Eurostat.

[21] GHG emissions from European Environment Agency inventory, direct fuel use from Eurostat energy balances.

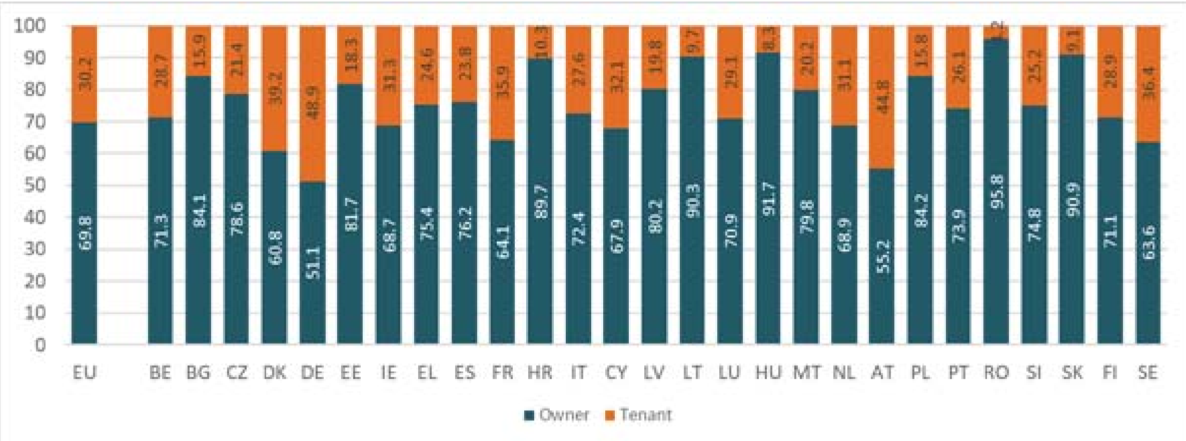
However, there are several countries such as Czechia, Germany, Greece, Spain, Italy, Malta and the Baltic countries where the majority of the population lives in flats.

Figure N.6 : Distribution of population by type of dwelling, 2019[22]



Most of the EU population (70%) lives in dwellings they also own (Figure 2.7). Although this is valid for all EU countries, the share of the population living in rented accommodation is much higher in Germany (49%), Austria (45%), Denmark (39%), Sweden (36%) and France (36%). In all EU countries, the problem of split incentives (see Chapter 2) is therefore present, although to a varying degree.

Figure N.7: Distribution of population by tenure status, 2019[23]



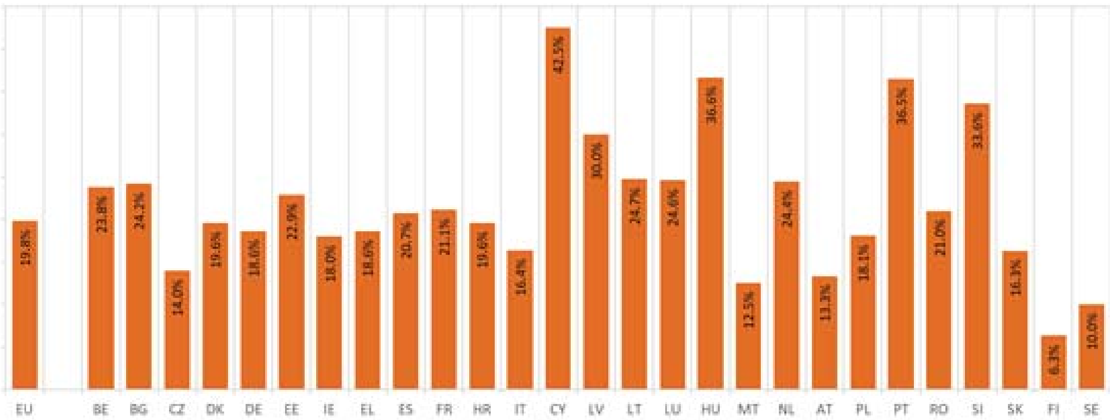
The population at risk of poverty (below 60% of median equivalised income[24]) represents 16.5% (or 74 million) of the total EU population, and the distribution by type of building

[22] Source: Eurostat-SILC.
[23] Source: Eurostat-SILC.
[24] Archive:Living standard statistics - median equivalised disposable income - Statistics Explained (europa.eu)

is slightly more for flats (51.5%), notably in Nordic countries, Baltic countries, Czechia, Germany, Spain, Italy, Malta and Austria (Figure N.6).

The poor energy performance of buildings leads to high energy costs and can affect the well-being and health[25] of people. In 2019[26], around 6.2% of the EU population had fallen behind on their utility bills, with Bulgaria and Greece close to 30%. Almost 7% of the EU population was unable to keep their home warm[27]. The inability to keep homes warm enough is also more likely to coincide with health issues for residents and/or structural building issues. The situation is much worse for the category at risk of poverty, for which the share of people in arrears on utility bills and unable to keep their homes adequately warm reached 14.9% and 18.2% respectively in 2019. These indicators are widely accepted as metrics to determine the group of people living in energy poverty.

Figure N.8: Population at-risk-of-poverty (% of population below 60% of median equivalised income) living in a dwelling with a leaking roof, damp walls, floors or foundation, or rot in window frames or floor, 2019[28]



According to the Eurostat survey on income and living conditions, around 20% of the population at risk of poverty (% of population below 60% of median equivalised income) lives in dwellings with a leaking roof, damp walls, floors or foundations, or with rot in window frames or floors (Figure N.8). Among EU countries, more than one third of the population at risk of poverty in Cyprus (42.5%), Hungary (36.6%), Portugal (36.5%) and

[25] A specific correlation analysis of 2012 EU-SILC data on housing conditions reveals for example that around 10% of adults living in single-family homes reported poor general health. With both structural problems (leaking roof, rot in windows etc.) and being unable to keep homes warm, this share increased to beyond 20%. Affected by these two issues, the reported level of dissatisfaction with homes reached around 40% across the EU, and even went beyond 50% in Central and Eastern European countries – both in single- and multi-family buildings.

[26] EUROSTAT statistics on income and living conditions (SILC): Statistics on Income and Living Conditions - Access to microdata - Eurostat (europa.eu), Arrears on utility bills - EU-SILC survey [ilc_mdes07].

[27] EUROSTAT statistics on income and living conditions (SILC): Inability to keep home adequately warm - EU-SILC survey [ilc_mdes01].

[28] Source: Eurostat-SILC.

Slovenia (33.6%) lives in dwellings with poor conditions. The problem of energy poverty in conjunction with unhealthy living conditions due to poor building status is therefore common across Member States.

Service sector (non-residential) buildings is a more complex and heterogeneous sector compared to the residential sector (Figure N.9). Office buildings (public and private) make up around a third of the non-residential floor area, while wholesale and retail buildings are the second biggest category with a floor space corresponding to around a quarter (23%) of the total non-residential floor space. School & education buildings (16%), hotels & restaurants (12.3%) and health-related buildings (8.5%) represent large parts of non-residential building stock. Variations in usage patterns, energy intensity, and construction requirements are some of the factors adding to the complexity of the sector.

Figure N.9: Distribution of services buildings by type of activity, 2018[29]

[29] Source: Odyssee database, Building Stock Observatory.