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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}

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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	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

regulatory overlap (e.g. with construction material standards).	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	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

drivers, even though the analysis shows that these are best tackled at Member State level due 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.	account the particularities of building stocks across different Member States, whilst maximising the magnitude of the 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 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.	Monitoring and reporting of this initiative will be grounded on the common tools established under the Governance 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.

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.

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

[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.

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

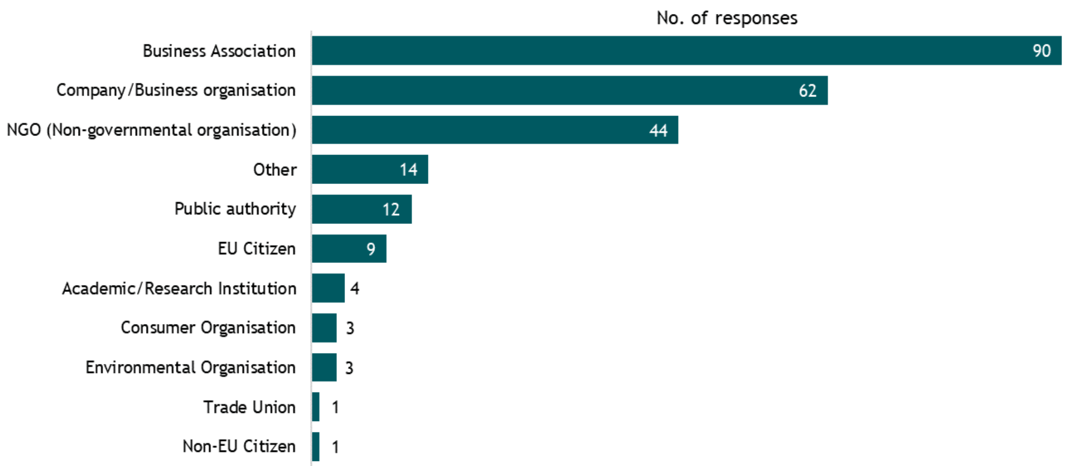
2. Outcome of the consultation activities

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)**

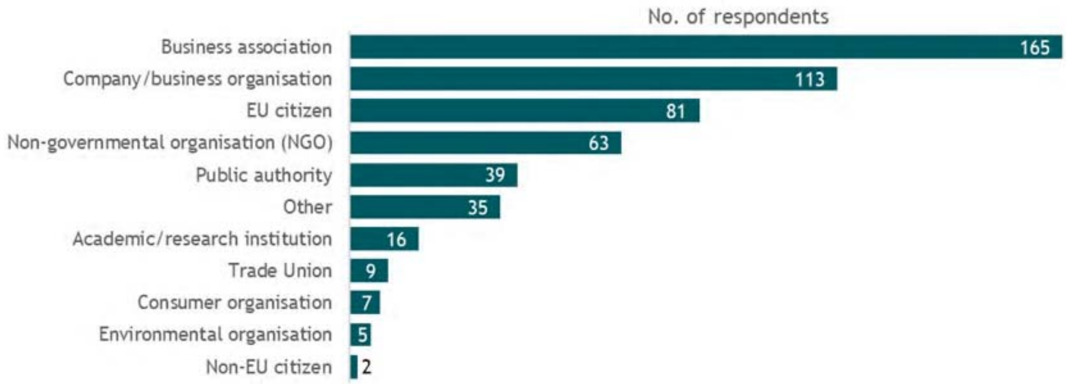
The SRI can be used to make building equipment comparable across Member States and helps to identify renovation needs. The SRI methodology should be simplified. The EPBD should establish a roadmap for the (voluntary) implementation of SRI and to accelerate its adoption.

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).

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[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]			

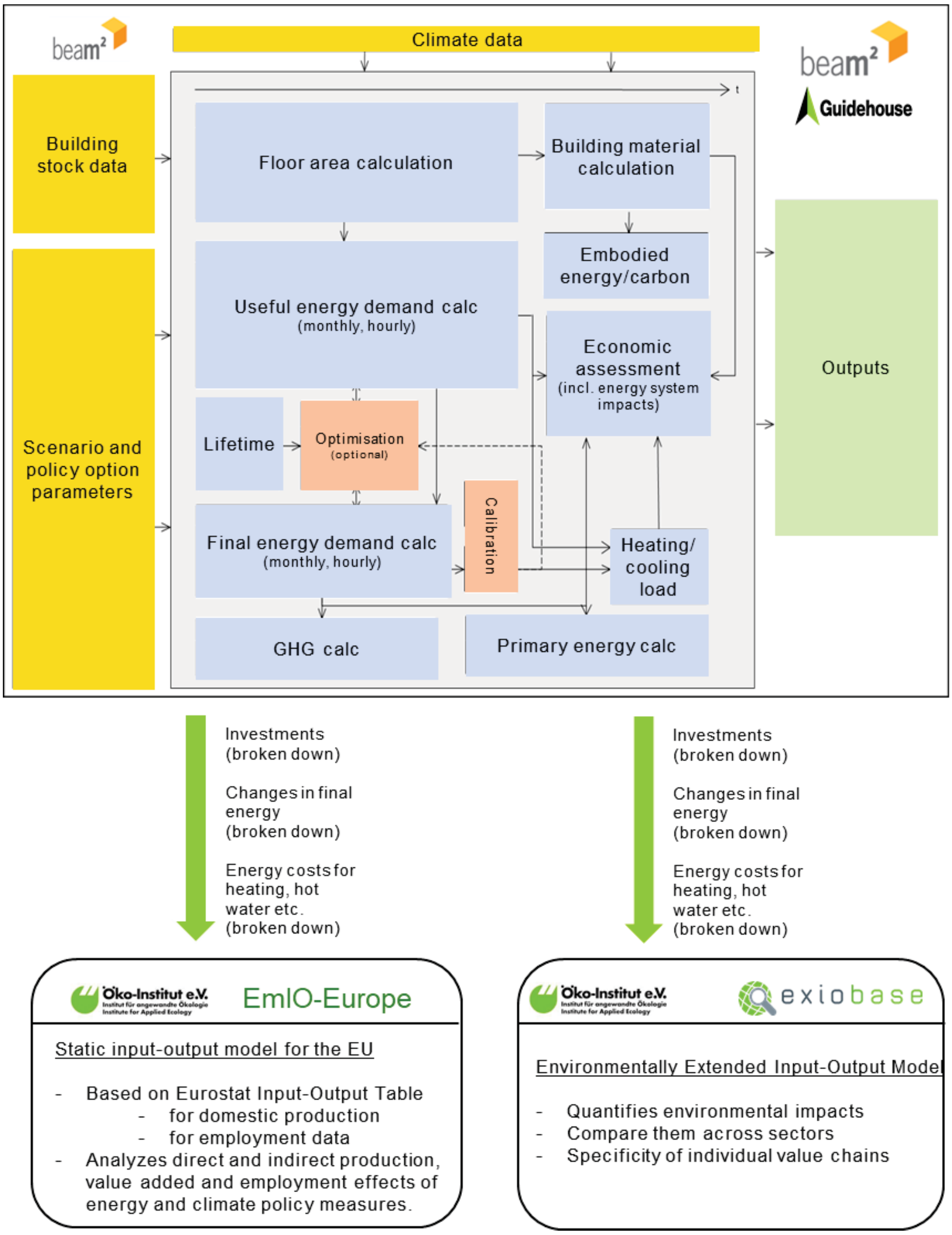
[12] Detailed explanations of the costs is provided in Annex I on e-mobility.

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.

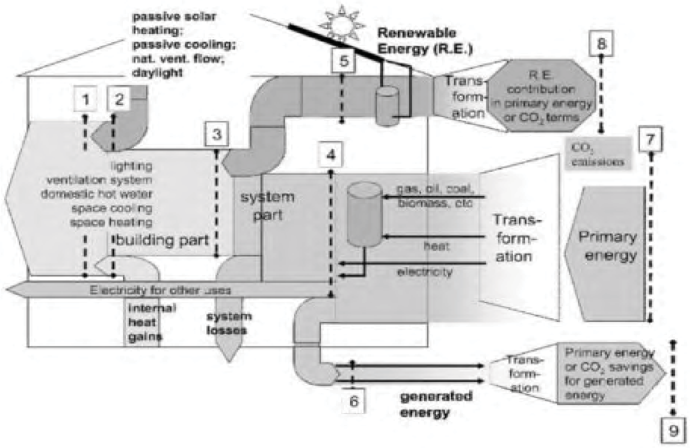
Terms and Definitions

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.

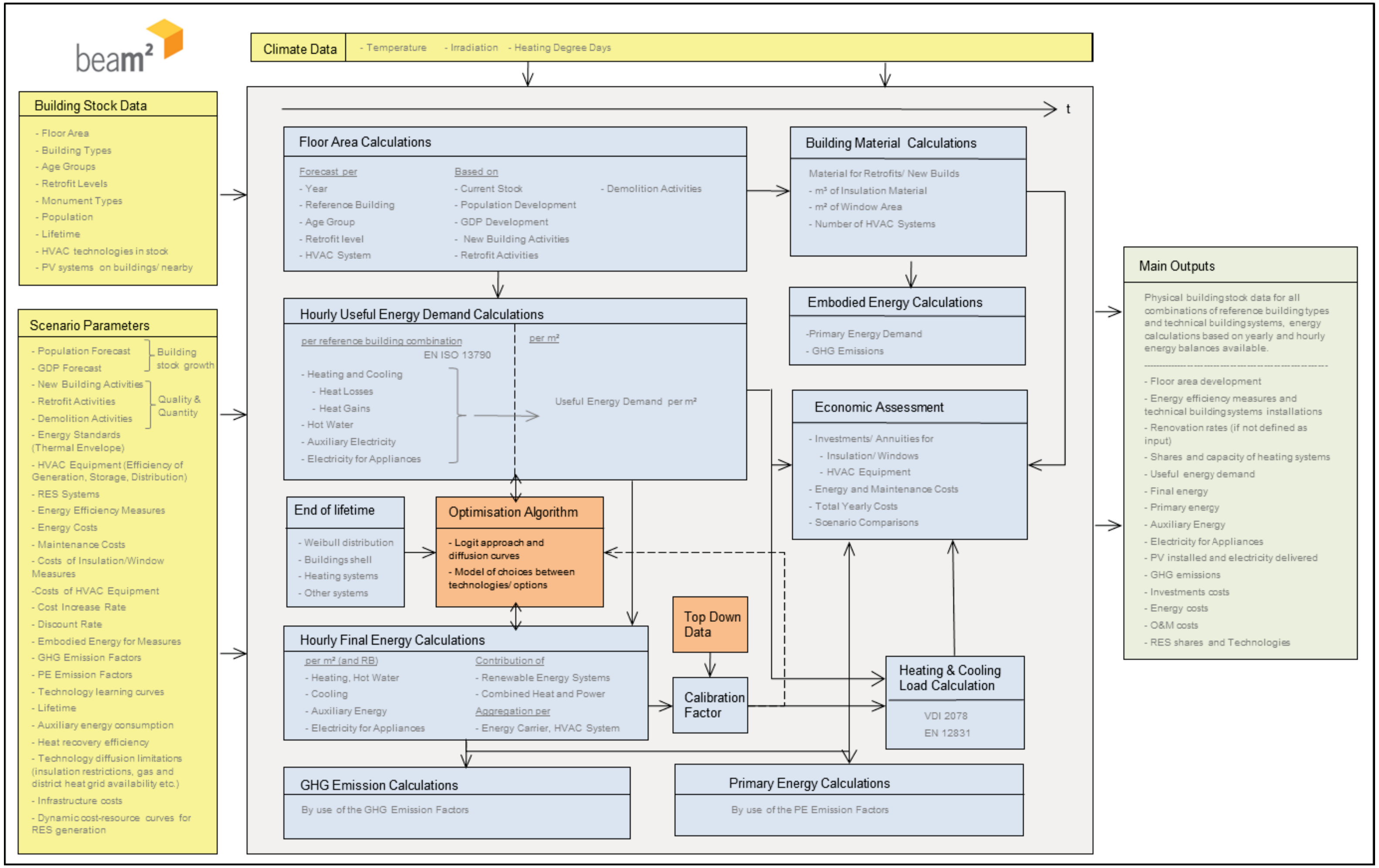
forecast for the floor area is done taking into account new building, demolition and renovation programs for all or parts of these combinations. All activities in year i have an effect starting in year i+1.

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].

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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

[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.

stock the following new construction and renovation target levels have been used to identify different level of efficiency of the building shell:

- 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/m²a
Investments[34]	-	84	212	Euro/m² floor area
Energy costs[35]	24	20	2.5	Euro/m² floor area

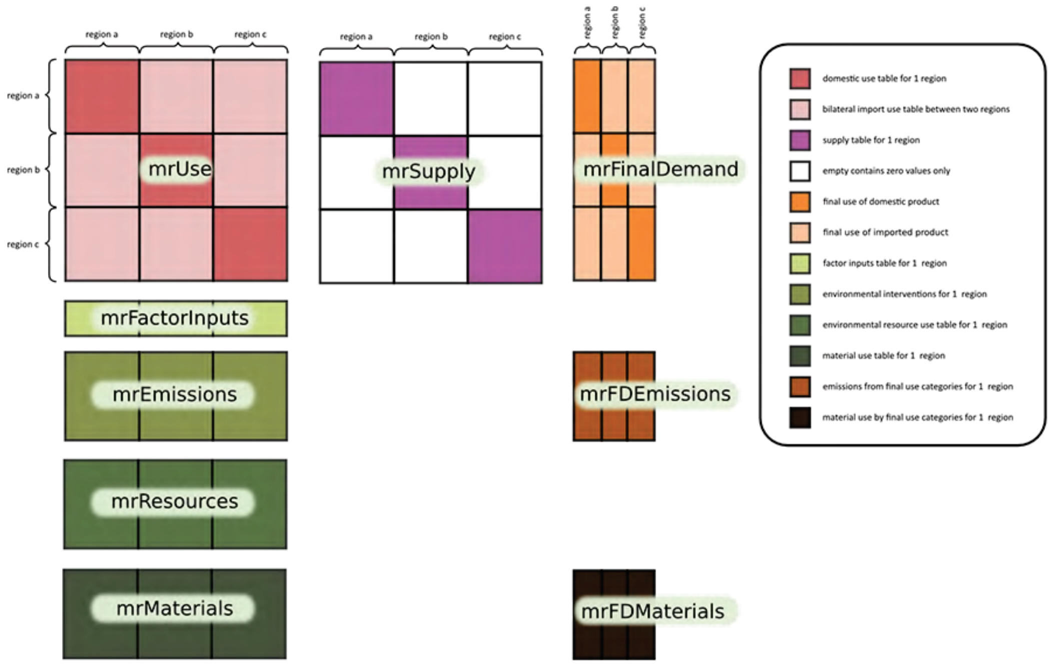
The table shows moderate reductions for the first step of the BRP when renovating the upper and cellar ceiling only (appr. -17%). Significant savings of about -90% can be achieved in a second step when the walls and windows are brought to passive house standard[36] as well.

[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 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.

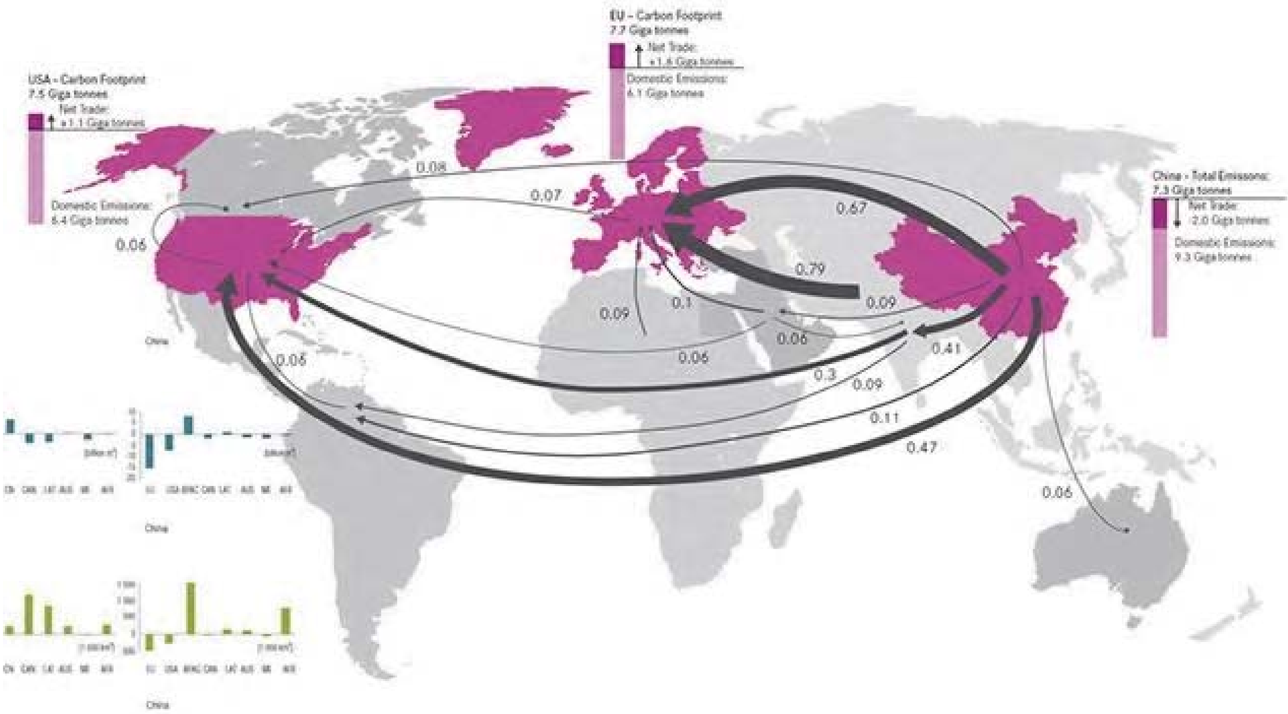
With the help of detailed environmental extensions, resource consumption and environmental impacts of individual economic sectors (manufacturers of the 200 different

[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.

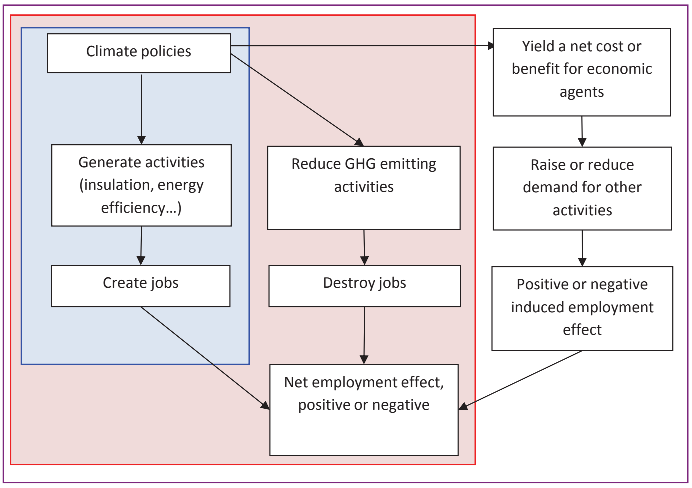
4. EmIO-Europe Employment I/O Model (EmIO-Model)

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

[40] Guidehouse (2021).

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 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

[41] EU Reference Scenario 2020 | Energy (europa.eu)

- 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

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.

Renovation rates

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

[42] Esser et al. 2019, Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU.

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 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.

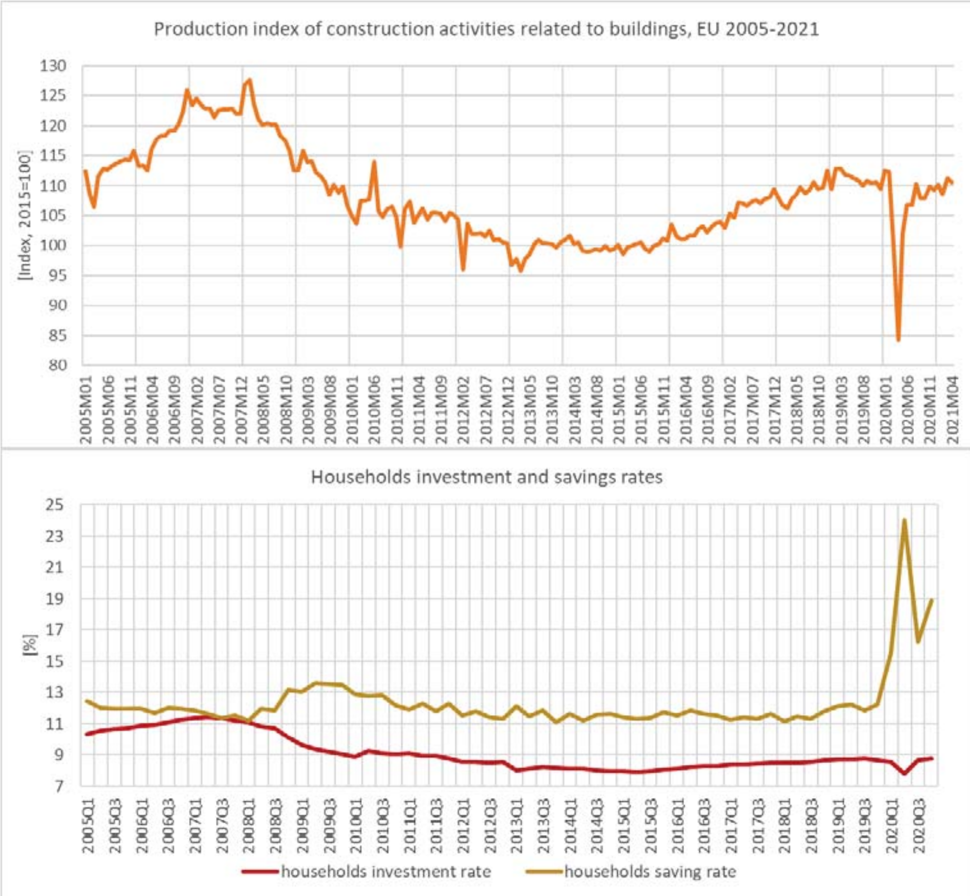
The EU construction sector is a major part of the EU economies that contributed with about 9% to the EU's GDP in 2019 and between 13 to 18 million direct jobs[43].

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

<u>Macro-economic modelling</u>

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.

<u>Social impacts</u>

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).

[48] https://ec.europa.eu/energy/sites/ener/files/recommendation_on_energy_poverty_-_annex.pdf

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

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.

[49] Hotmaps Project - The open source mapping and planning tool for heating and cooling (hotmaps-project.eu)

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 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.

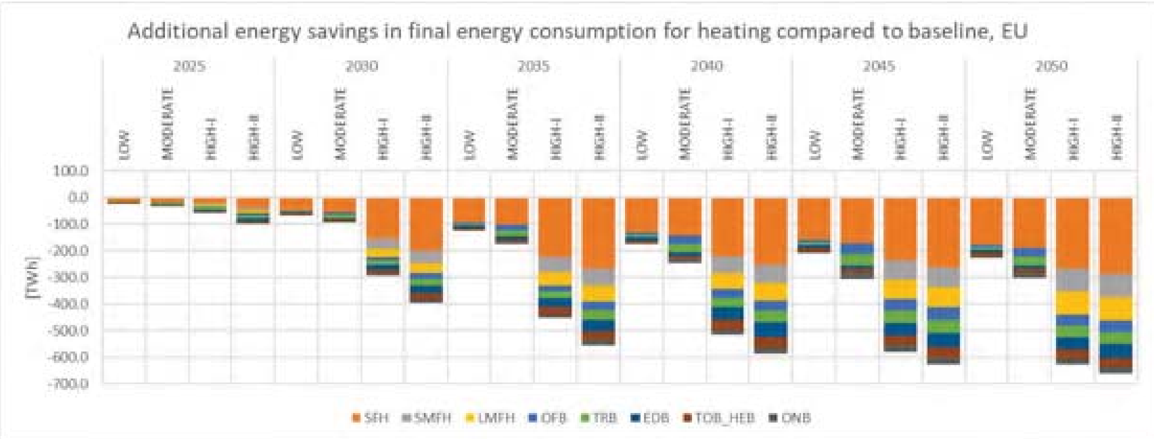
8. Modelling results

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)

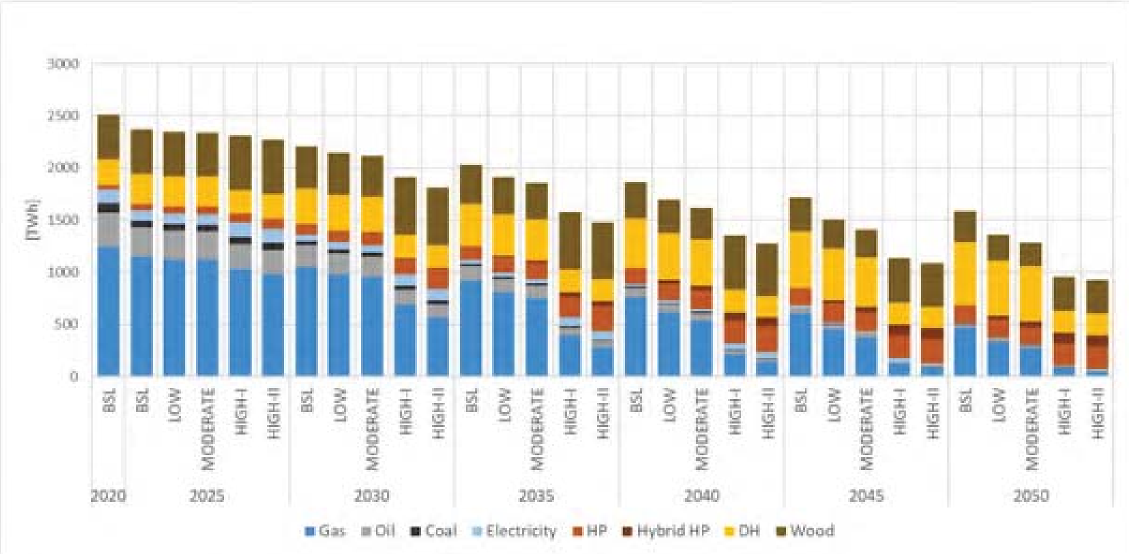


Source: Guidehouse et.al.

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.

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

[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).
[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

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.

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]

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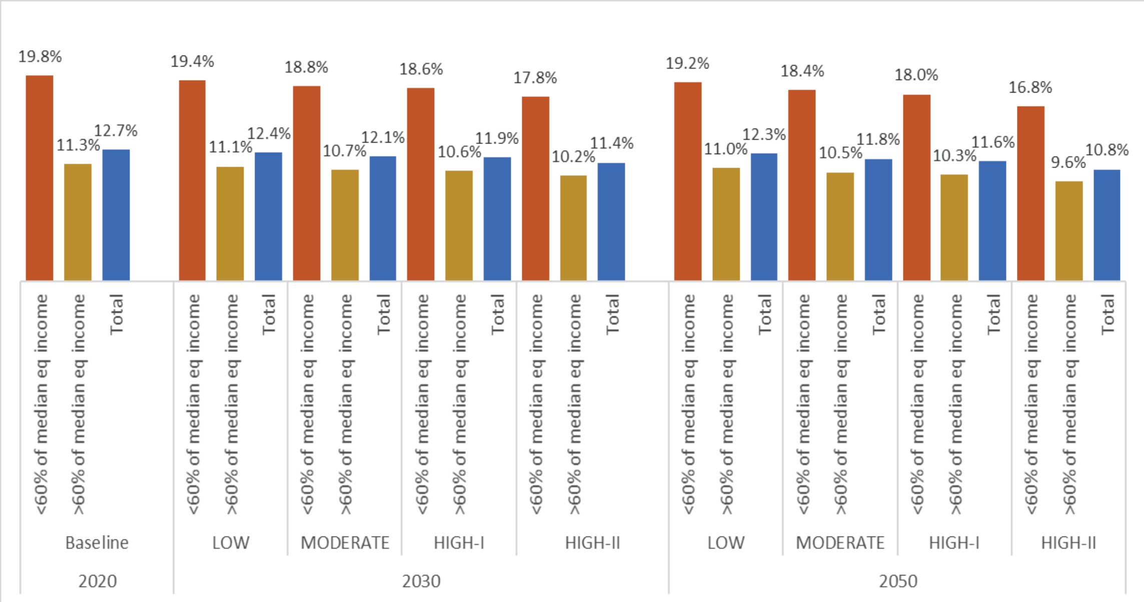
peak loads. This leads to an assumed 70/30 distribution of heat supplied from the heat pump part vs. the gas boiler part of the hybrid system.

[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.

[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.

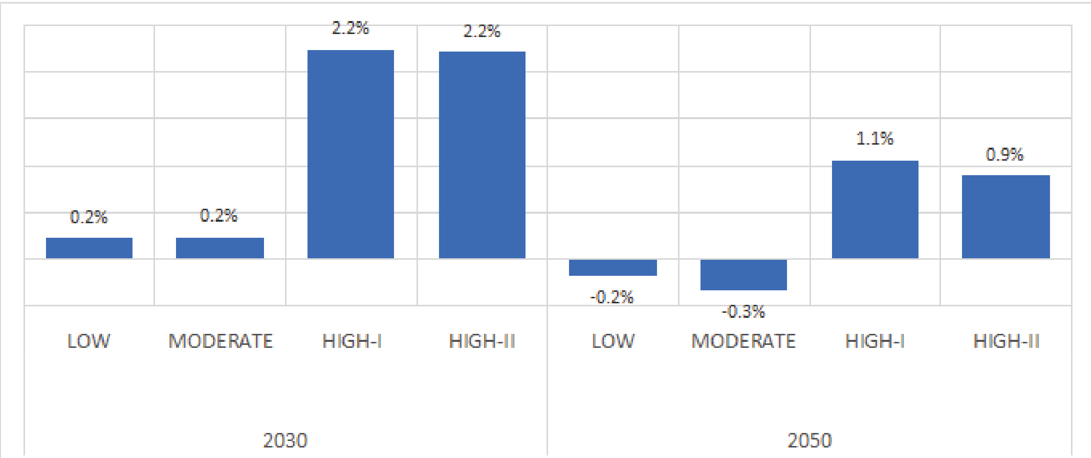
[54] Guidehouse (2021) based on Eurostat (ilc_mdho01)



Source: 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 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

[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.

[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).

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 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

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[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).

[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)

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.

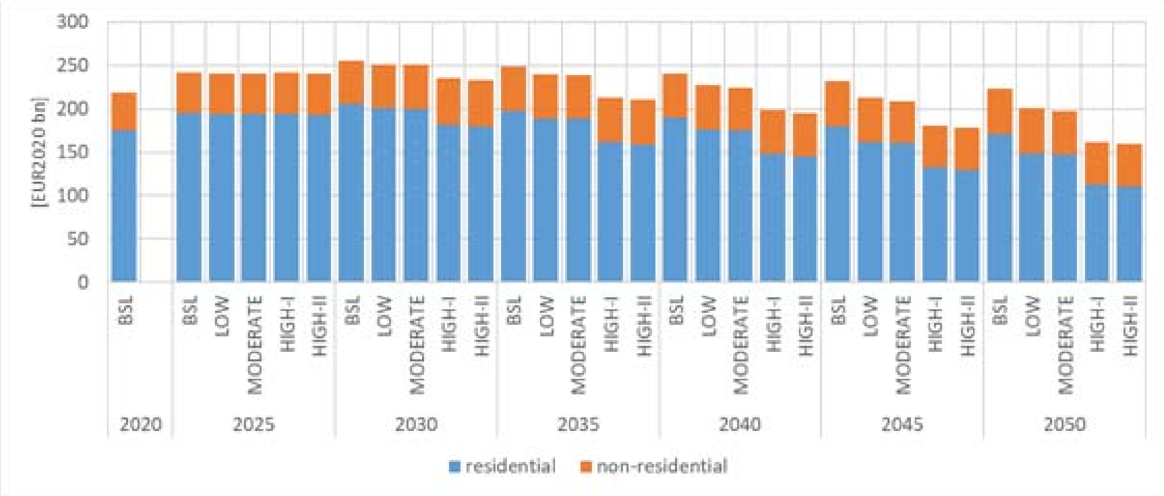
Energy costs

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 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.

[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.

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

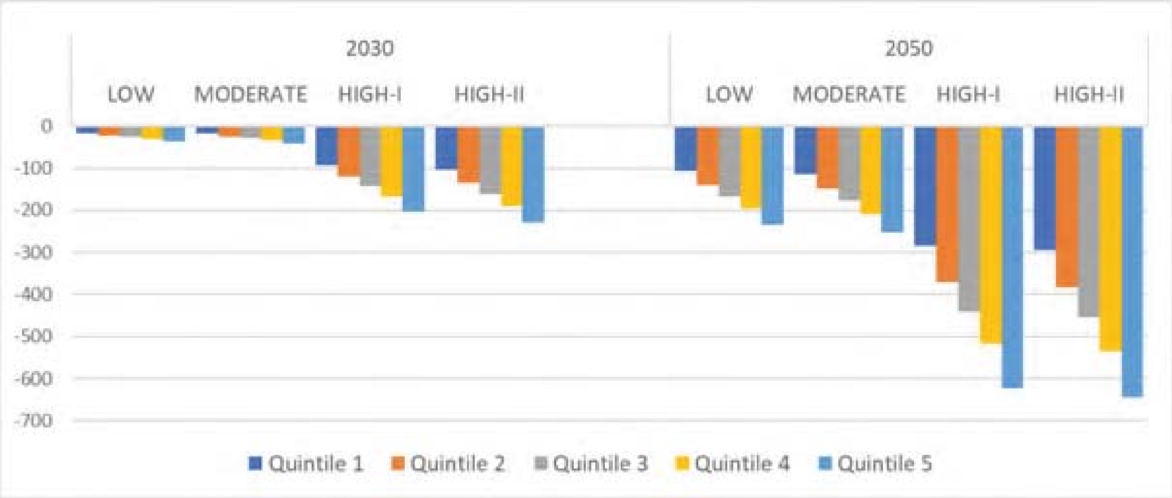
It is expected that the effects in costs reductions will be more pronounced in low-income groups as worst performing buildings are occupied in relative higher shares by low-income households[64]. The quantitative effect is however difficult to assess because the share of low-income population living in worst performing buildings is not known. If assumed that renovations and subsequent energy savings are distributed proportionally to 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]

[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

[65] Guidehouse *et al.* (2021) based on Eurostat (hbs_str_t223).



Source: Guidehouse et al.

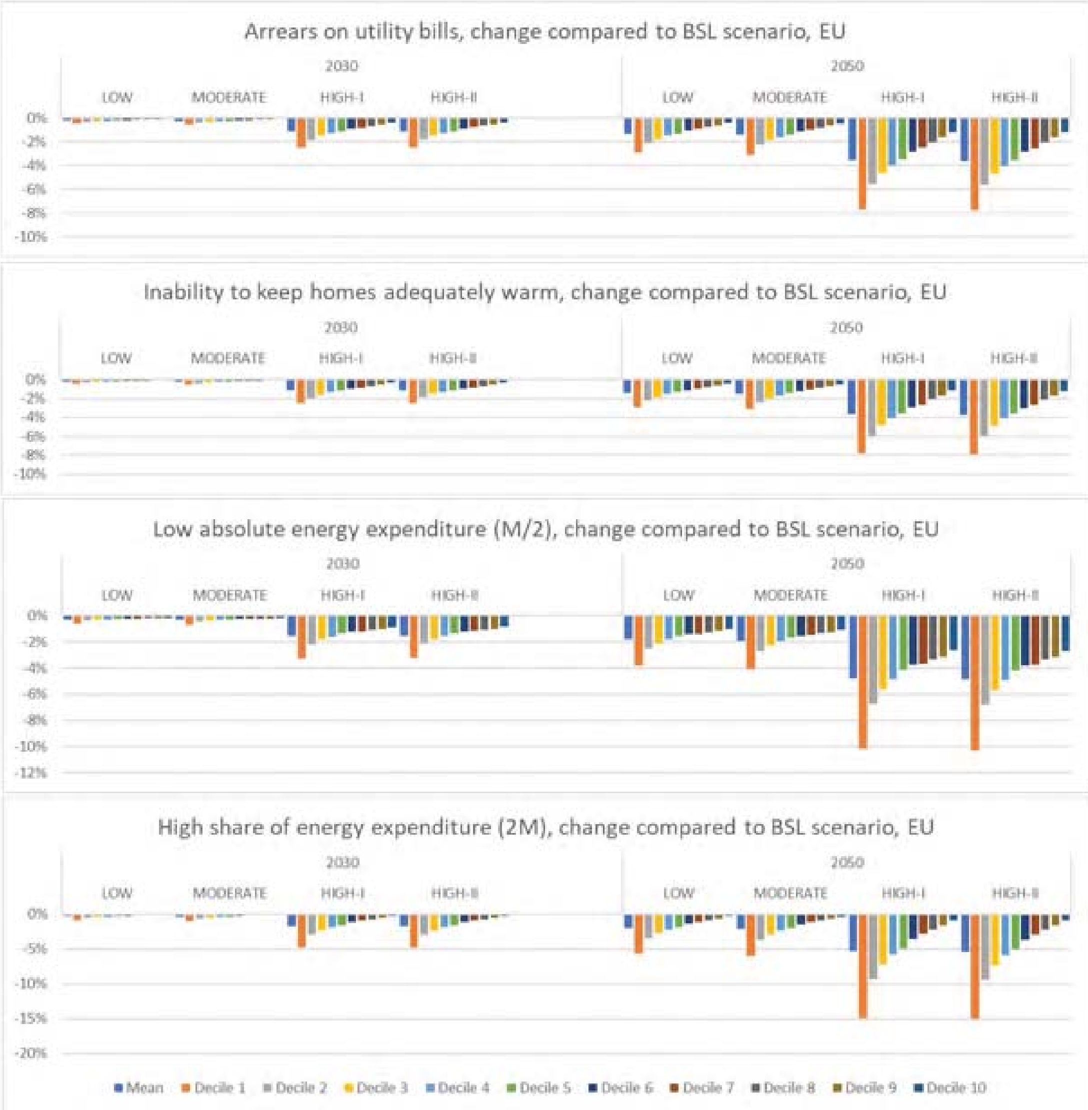
Respiratory infectious diseases that occur due to indoor air tightness can be avoided by insulation and adequate ventilation systems. Thermal insulation and an upgrade of the heating or ventilation system can prevent indoor cold and dampness, avoid unhealthy conditions and decrease the cases of cold 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 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]

[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 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)



Source: Guidehouse et.al.

8.3.1. Results of sensitivity analysis for distributional impact and financial support for low-income households undertaking renovation

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											
		Share of owners (%)		Annual household Income		affected low income households (< 60% median, i.e. 30% of all households)	Investment per SFH	Energy savings			
MS-Region	MS (highest share of owners 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	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			Scenario 2, investment grant (25%)			Scenario 3, investment grant (60%)			Scenario 1 - no invest. support	Scenario 2 - 25% invest support	Scenario 3 - 60% invest support
	Investment cost*	Possible increase of housing cost (% of income)		Investment cost (net of subsidy)	Possible increase of housing cost (% of income)		Investment cost (net of subsidy)	Possible increase of housing cost (% of income)		Net Effect - Housing cost 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	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											
		Share of owners (%)		Annual household Income		affected low income households (< 60% median, i.e. 30% of all households)	Investment per SFH	Energy savings			
MS-Region	MS (highest share of owners 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	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%

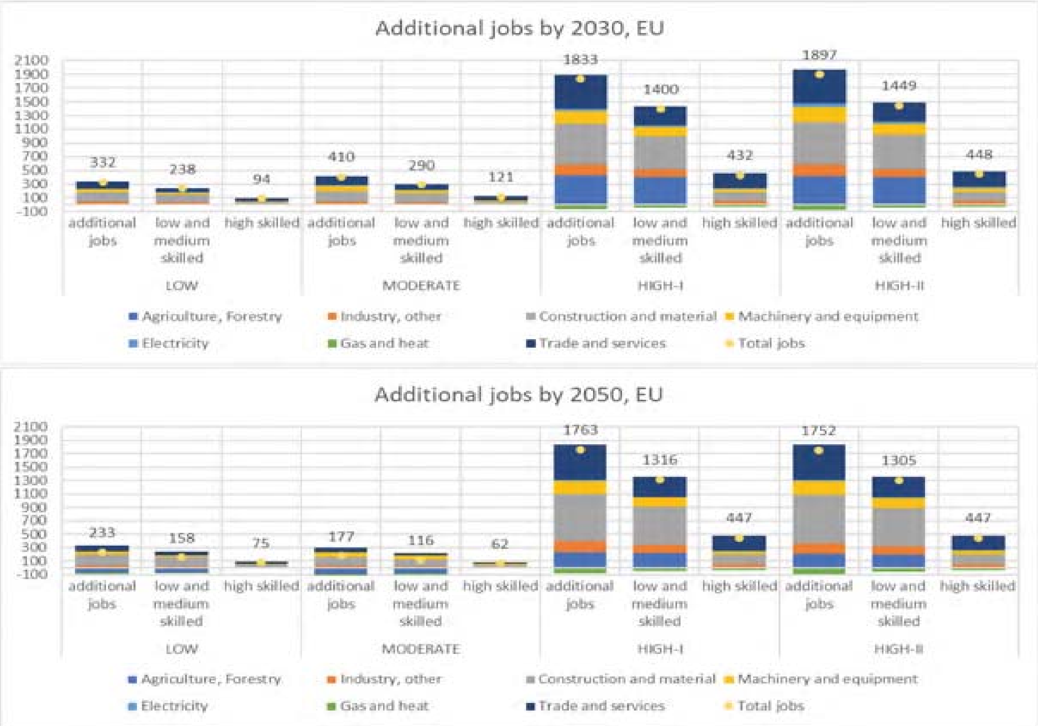
*annualised costs over 30 years period and with 6% discount rate

EU Region	Scenario 1 - full cost pass through, no investment support			Scenario 2, investment grant (25%)			Scenario 3, investment grant (60%)			Scenario 1 - no invest. support	Scenario 2 - 25% invest support	Scenario 3 - 60% invest support
	Investment cost*	Possible increase of housing cost (% of income)		Investment cost (net of subsidy)	Possible increase of housing cost (% of income)		Investment cost (net of subsidy)	Possible increase of housing cost (% of income)		Net Effect - Housing cost 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	1,457 €	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.

Value added

Figure D.22: Impact of renovation and new-build investment and reduced energy consumption on value added at the EU level[69]

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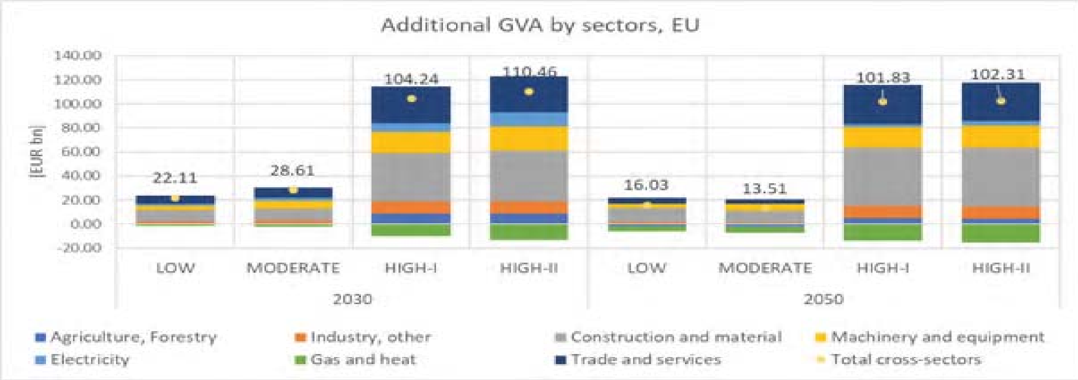
[68] Exiobase modelling, absolute values estimated based on changes of domestic consumption induced by the investment impulse in the affected sectors (conservative approach)



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	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							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) [%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	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.

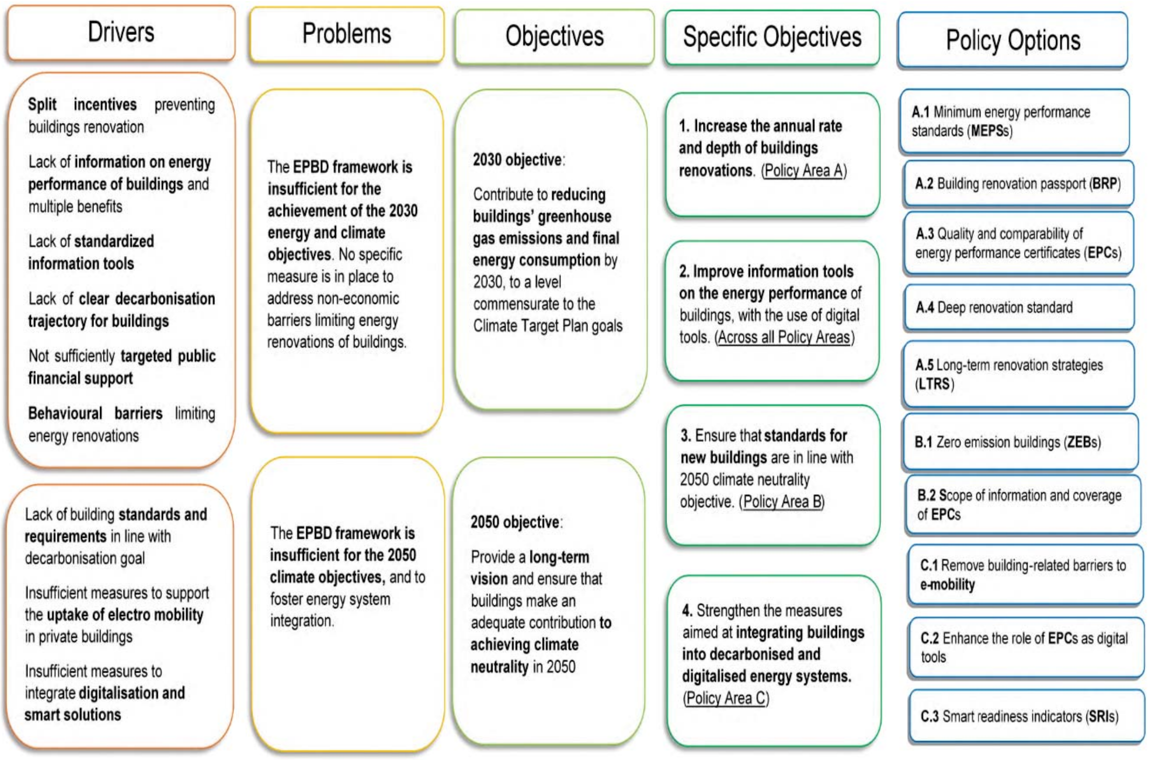
At the same time drivers representing all other DEGD policies are “frozen” on their level of ambition/stringency as modelled in MIX.

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

No.	Policy action - general	Timeline	Sub-options
	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	Guidance by 2023	a) Support integration of SRI in other

[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
	other information tools	MS to achieve 2025	tools (e.g. building renovation 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