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Explore sustainable European futures

Initial results from EUCalc

Pathways Explorer for the building sector: European and Member States insights

D2.8

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Short Description
This briefing provides a practical example of how policymakers can use the EUCalc model. Notably, the model can create pathways to mirror the Energy Performance of Buildings Directive long-term renovation strategies with different levels of ambition. It contains projections of energy demand and CO_2 emissions from heating buildings. The purpose and functioning of the EUCalc, and how it has been used for the purpose of this briefing, is explained in detail. This report will be updated by the end of 2019.

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Name of reviewer	**Date**
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This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

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List of abbreviations

BEMS – Building energy management systems

CHP – Combined heat and power plants

EED – Energy Efficiency Directive

EPBD - Energy Performance of Buildings Directive

GHG – Greenhouse gas

gCO_2e – Grams of carbon dioxide equivalent

ICT – Information and communications technology

kWh_{therm} – Thermal kilowatt-hour

kWh_{fuel} – Kilowatt-hour in fuel

LTRS – Long-term renovation strategy

MFH – multi-family house

MJ – Megajoule

NECP - National energy and climate plan

NZEB – Nearly zero-energy building

SFH – Single-family house

Glossary

Floor area – living space in residential buildings and used floor space in non-residential buildings

Conditioned space – floor area that is heated, cooled or ventilated

Shallow renovation – energy renovation of the complete building reducing its energy need by 30% on average

Medium renovation – energy renovation of the complete building reducing its energy need by 40% on average

Deep renovation – energy renovation of the complete building reducing its energy need by 60% on average

Inefficient new build – new build that is on average only 30% more energy efficient than the average building stock

Medium efficient new build – new build that is on average 40% more energy efficient than the average building stock.

Highly efficient new build – new build that is on average 60% more energy efficient than the average building stock. The NZEB definition was not used as it varies across EU Member States and, in some cases, new builds in line with NZEB are not highly energy efficient buildings.

1 Executive Summary

EUCalc is a new dynamic modelling tool able to create pathways for sectoral energy demand, GHG trajectories and social implications of lifestyle and energy technology choices in Europe. In this briefing, EUCalc is used to create GHG emissions reduction pathways in the buildings sector that try to mirror Long-term renovation strategies (LTRS) in line with the Energy Performance of Buildings Directive (EPBD). We analyse what this could mean in term of impacts for the EU, selected Member States and for achieving the EU 32.5% energy efficiency target by 2030.

While EUCalc is able to model integration between different sectors, the pathways for this briefing have been generated by using the EUCalc building module only and keeping all inputs from other modules, including the EUCalc Power module, at a level of ambition that corresponds to "observed trend continuation".

The most ambitious pathway created for this briefing (level 4 pathway) shows an almost total decarbonisation of the demand and supply of heat in buildings in the EU, resulting in a decrease of CO_2 emissions of 97% compared to 2015. This reduction can be considered consistent with the legal obligation of the EPBD that requires Member States to develop LTRSs that achieve a highly energy efficient and decarbonised building stock by 2050.

In addition, this briefing shows that if Member States adopt and implement LTRSs that achieve the 2050 decarbonisation objective (in line with the level 4 pathway), and plan intermediate milestones for 2030 accordingly, these measures could contribute around 36% of the 2030 EU energy efficiency target.

By modelling this pathway with EUCalc, it is also possible to have an indication of the scale of the impacts Member States need to achieve. When Member States draft and implement LTRSs that are in line with the requirements of the EPBD, they must put in place policies and measures that lead to a transformation of the building sector compared to today. For example, the level 4 pathway assumes a renovation rate of 3% leading to a refurbishment of all existing buildings by 2050. Out of these renovations, the great majority are assumed to be deep renovations with no shallow refurbishment. The demolition rate is about 1% per year.

To achieve a similar level of impacts, Member States must use the drafting of their LTRS, due by 10th March 2020, as an occasion to rethink their policy interventions in the buildings sector and put in place a coherent strategy that mobilises resources and actors towards the long-term decarbonisation goal.

This briefing concludes that large additional effort and major technological advances and breakthroughs compared to the buildings sector's current construction and renovation practices are possible and necessary if Member States are serious in drafting roadmaps that will lead to a highly energy efficient and decarbonised building stock by 2050. If LTRSs are drafted with this ambition in mind, they will also make a significant contribution to the achievement of the 2030 energy efficiency target and will be the driver for accelerating actions by 2030.

2 Introduction

Buildings account for about 36% of CO_2 emissions and 40% of energy consumption in Europe[1] and 97% of the existing building stock is inefficient.[2] This means that a comprehensive strategy to reduce emissions from the buildings sector is needed if the European Union wants to meet the objectives of the Paris Agreement[3] and to become "the first climate-neutral continent in the world by 2050", as suggested by Commission President-elect Ursula von der Leyen.[4] In line with the energy efficiency first principle, reducing energy demand from the buildings sector must be prioritised as it is often the cheapest and most effective way to reduce carbon emissions.

With the Clean Energy for All Europeans package recently adopted and now to be transposed in national legislation, Member States have the opportunity to plan policies that go in that direction. For example, the Energy Performance of Buildings Directive (EPBD) already requires Member States to draft a long-term renovation strategy (LTRS) to achieve a highly energy-efficient and decarbonised national building stock by 2050.

With the help of the newly developed European Calculator (EUCalc) model, we are able to present first insights into how the buildings sector in the EU could contribute to greenhouse gas (GHG) emissions reductions until 2050. EUCalc is a new model to provide decision-makers and interested stakeholders with a user-friendly online interface to quantify the sectoral energy demand, GHG trajectories and social implications of lifestyle and energy technology choices in Europe.

For this briefing, EUCalc has been used to create pathways that try to mirror the LTRS in line with the EPBD requirements. The briefing also looks at the implications of designing LTRSs that are aligned with those pathways, also in terms of their contribution to the EU 2030 energy efficiency target.

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[1] https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-performance-of-buildings/overview

[2] Building Performance Institute Europe (BPIE), 2019

[3] The Paris Agreement's central aim is to strengthen the global response to the threat of climate change by keeping average global temperature rise this century well below 2° Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5° Celsius. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

[4] See Opening Statement in the European Parliament Plenary Session by Ursula von der Leyen, Candidate for President of the European Commission, on 16 July 2019. Available at https://ec.europa.eu/commission/presscorner/detail/en/speech_19_4230

3 Policy context

The European Union has recently adopted a new package of climate and energy legislation, the Clean Energy for all Europeans package,[5] to facilitate the transition towards a cleaner energy system and to help the EU meet the commitments of the Paris Agreement. Member States must now implement the different pieces of legislation, including the revised Energy Efficiency Directive (EED) and the amended EPBD.

The EED sets the overarching framework of energy efficiency policy in the EU, including the overall energy efficiency target for 2030, while the EPBD sets specific rules for energy performance of buildings, including for the construction of new buildings and for the renovation of existing ones. The two directives are, however, intrinsically linked as measures in the buildings sector are essential to achieve the 2030 energy efficiency target.

3.1 EPBD long-term renovation strategies

According to the EPBD Article 2a[6], Member States must submit their LTRS by 10 March 2020. An LTRS is a strategic planning document with a national roadmap for achieving a highly energy-efficient and decarbonised national building stock by 2050 and for facilitating the cost-effective transformation of existing buildings into nearly zero-energy buildings. While LTRSs focus on renovations, they also cover new builds.

In addition to the long-term decarbonisation objective, the LTRS must include indicative milestones for 2030, 2040 and 2050 and specify how they contribute to the energy efficiency targets. This includes the European Union's overall target of improving energy efficiency by 32.5% by 2030.

These milestones can be qualitative or quantitative. The European Commission guidance note[7] gives the following non-exhaustive list of examples of milestones:

1. Energy savings (in absolute and relative percentage terms) per building sector (residential, non-residential)
2. Percentage of renovated buildings (per renovation type)
3. CO_2 emissions reduction in the buildings sector (renovation/new buildings)
4. Percentage of nearly zero-energy buildings (NZEBs) per building sector
5. Percentage reduction in people affected by energy poverty
6. Percentage reduction of buildings in the lowest energy class
7. Energy savings in public buildings

[5] https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans
[6] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L0844&from=EN
[7] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1557922398528&uri=CELEX:32019H0786

8. Percentage of buildings equipped with a building energy management system (BEMS) or similar smart system, per building type
9. Number of one-stop-shop initiatives
10. Raised awareness leading to concrete action.

3.2 2030 energy efficiency target

The EED[8] establishes an EU headline target of reducing energy consumption by at least 32.5% by 2030 (Article 1). This target is calculated as a reduction of 32.5% compared to projected energy use in 2030. It translates in a requirement that the EU should not consume more than 1,273 Mtoe of primary energy and/or no more than 956 Mtoe of final energy in 2030.

Member States must communicate to the European Commission their indicative national energy efficiency contributions, which represent their share of the EU target. Those contributions were submitted through the draft national energy and climate plans (NECPs), which were due on 31 December 2018.[9]

The Commission aggregated the national contributions it received from the Member States and found that, with the current draft plans, there would be a gap towards the achievement of the overall EU energy efficiency target of up to 6% in final energy and up to 6.2% in primary energy terms.[10] However, Member States that have suggested contributions that are too low, or that have not submitted them at all, can still rectify them in the final version of their NECPs due by the end of this year.

Energy savings achieved through energy efficiency measures in the buildings sector are key to meeting the 2030 energy efficiency target. In particular, when setting their national objectives and targets for energy efficiency in their NECP, Member States must also outline the indicative milestones under the LTRS.

[8] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2002&from=EN

[9] The integrated national energy and climate plans are 10-year planning documents for climate and energy policies that Member States must submit to the European Commission in compliance with the Governance Regulation, https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/governance-energy-union/national-energy-climate-plans

[10] According to the European Commission, only a few Member States have submitted adequate contributions to the EU energy efficiency target. Those are Italy, Luxembourg and Spain (both primary energy consumption and final energy consumption), Netherlands (for primary energy consumption) and France (for final energy consumption). Some Member States have not yet submitted yet their contributions. The European Commission has calculated the gap to the EU efficiency target by making assumptions on the missing contributions, https://ec.europa.eu/energy/sites/ener/files/documents/recommondation_en.pdf

4 EUCalc model and how it is used for this briefing

EUCalc is a new dynamic modelling tool able to create pathways for sectoral energy demand, GHG trajectories and social implications of lifestyle and energy technology choices in Europe. For the purpose of this briefing, the EUCalc building module has been used to create pathways that mirror EPBD LTRS.

This chapter explains the architecture of EUCalc, the functioning of its building module and how this module has been used to create pathways that resemble LTRSs.

4.1 What is the goal of the EUCalc model?

EUCalc's scientific mission is to develop a sophisticated, yet accessible, model to fill the gap between integrated climate-energy-economy models and the practical needs of decision-makers. Its easy-to-use web version allows users to construct transformation pathways, and explore and compare their impacts.

EUCalc aims to provide policy- and decision-makers with a highly accessible, user-friendly, dynamic modelling solution and planning tool. As well as delineating emission and sustainable transformation pathways at a European scale, EUCalc may also be used to design country pathways (EU 28 Member States and Switzerland) and investigate how these could contribute to European scenarios.

EUCalc models energy, land, materials, product and food systems at European and Member State level representing GHG emissions dynamics until 2050. It explores different sectors, including transport, buildings, industry, agriculture, power generation, energy usage and lifestyles. The pathways explorer enables users to address technological and societal challenges and to evaluate trade-offs and co-benefits of sector decisions.

For this report, the building module of version 2.2 of the EUCalc model was used.

4.2 Overview of the EUCalc modelling approach

The EUCalc model covers different sectors such as transport, buildings and land use in separate modules and integrates their interactions,[11] as shown in figure 1. As the model was not fully functional when this briefing was written, this briefing does not use the full functionalities of the model; its scope and assumptions are further explained in section 4.4 and Annex I (page 6).

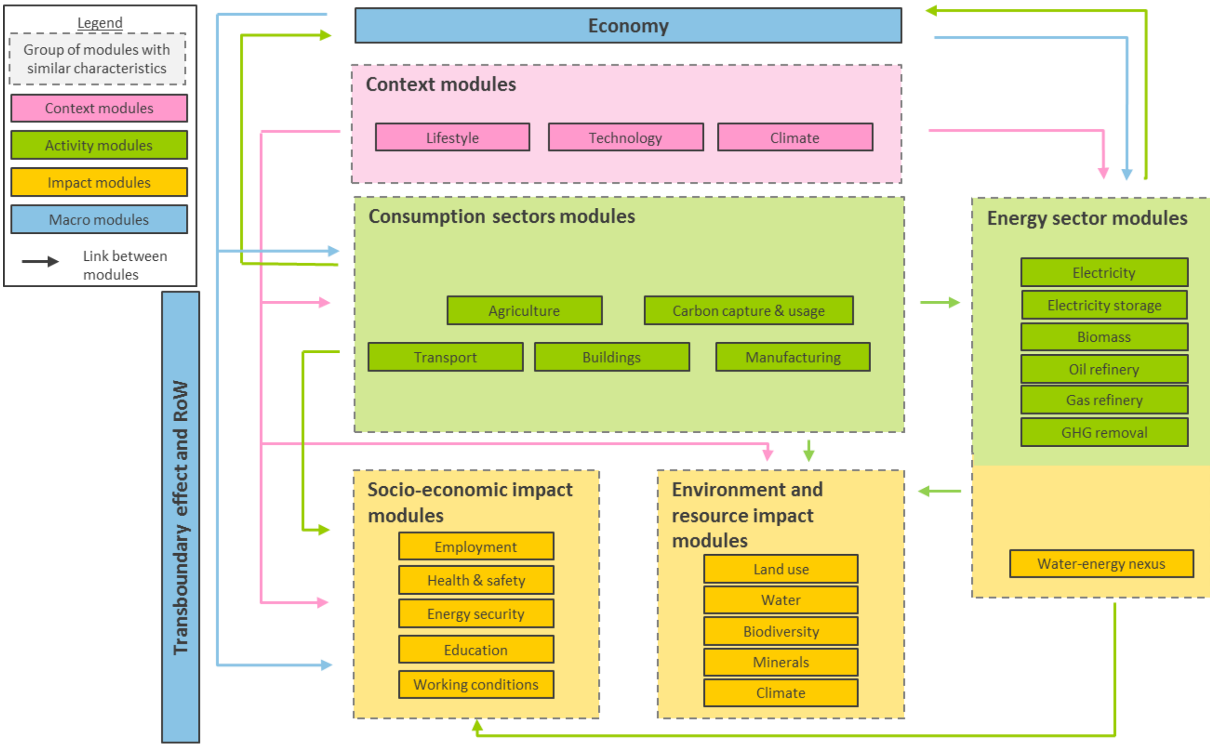

Figure 1: Overview of the EUCalc model architecture

EUCalc allows the user to modify the drivers (called "levers" in the model) that have an impact on GHG emissions for any module.

Each of the levers has four defined positions representing the ambition of the decarbonisation effort in that sector. Table 1 below summarises the four levels of ambition and table 2 defines the parameters for these levels. The model allows the user to choose the ambition level of each individual lever (from a level representing observed trends up to maximum technological ambition), enabling them to explore different scenarios or pathways for GHG emissions reductions up to 2050.

Projections of end-use service demand (e.g. buildings heating, appliances usage, car travel, freight demand, etc.), demographic evolution and techno-economic trends are defined by the user for each country (or for Europe as a whole) by moving pre-defined levers. In addition, the user can choose the amount of GHG the rest of the world and Europe can still emit to have a two-thirds chance of staying below 1.5° or 2° warming until the end of the century.

[11] Interactions of the building module are described in section 4.3.

Table 1: Lever level definition used for all modules in the EUCalc tool

Level 1	**Level 2**
This level contains projections that are aligned and coherent with observed trends.	This level is an intermediate scenario, more ambitious than business as usual but not reaching the full potential of available solutions.
Level 3	**Level 4**
This level is considered very ambitious but realistic, given current technology evolutions and best practices observed in some geographical areas.	This level is considered as transformational and requires large additional efforts such as strong changes in the way society is organised, very fast market uptake of highly ambitious measures, increased development of infrastructures, major technological advances and breakthroughs.

Table 2: Lever level definition for the building levers

Driver / lever		**Level 1**	**Level 2**	**Level 3**	**Level 4**
building envelope					
renovation rate per annum		1%[12]	1.5%	2%	3%[13]
renovation mix[14] (depth or energy ambition)	shallow[15] medium deep	80% 15% 5%	20% 60% 20%	10% 70% 20%	0% 30% 70%
demolition rate		0.1%	0.4%	0.7%	1%[16]
construction mix[14]	inefficient medium efficient highly efficient	80% 15% 5%	20% 60% 20%	10% 70% 20%	0% 30% 70%
heating efficiency[17]		gas 85% wood 65% oil 81%	gas 87% wood 66% oil 83%	gas 91% wood 69% oil 87%	gas 97% wood 74% oil 93%
heating technology and fuel share [18]	reduction of fossil fuels	gas -5% coal -30% oil -10%	gas -50% coal -80% oil -50%	gas -65% coal -90% oil -65%	gas -95% coal -95% oil -95%
	substitution	30% heat pumps 70% biomass	40% heat pumps 60% biomass	50% heat pumps 50% biomass	70% heat pumps 30% biomass

[12] The observed renovation rate lies at 0.5-2.5% (D'Agostino *et al.*, 2016 p. 58; Dean *et al.*, 2016 p. 3; Buildings Performance Institute Europe (BPIE), 2011, p. 103; Hansen, 2005, p. 10)
[13] As a maximum 3% is commonly used for the renovation rate and the whole building stock would be renovated between today and 2050 (European Commission, 2018, p. 90 ; Bettgenhäuser *et al.*, 2014, p. 1 ; Boermans *et al.*, 2012, p. 4 ; Buildings Performance Institute Europe (BPIE), 2011, p. 103 p.3.) However, expert opinion suggests such a renovation rate is not likely to be achieved (Sandberg *et al.*, 2016, p. 10).
[14] Level 1 continues the trend that most observed renovations entail no more measures than the minimum requirements (Umwelt *et al.*, 2018). The low share of efficient renovations and new builds is reflected in the dominant share of shallow and medium renovations. The Level 4 scenario assumes the majority of renovations to include very ambitious measures.
[15] The energy need is reduced by 30% in the shallow category, by 40% in the medium category and by 60% in the deep renovation category.
[16] Lowest and highest value in Sandberg *et al.*, 2016, p. 9
[17] The presented assumptions for heating efficiencies represent the aggregate of distributions across different technologies, sizes and their shares across the European building stock gathered by country in Fleiter *et al.*, 2016.
[18] The assumptions for the heating technology and fuel share are aligned with Fleiter *et al.*, 2016.

4.3 Overview of the EUCalc modelling approach for the buildings sector

The building module within the European Calculator follows a modular approach where the delivered energy depends on the evolutions of the floor area,[19] the energy need[20] and the heating systems efficiency. The GHG emissions are calculated using GHG factors specific to the fuel and to the applied heating technology, as shown in the last row of figure 2. The details on the left explain the underlying factors contributing to the evolution of the GHG emissions for buildings,[21] for example the different buildings typologies, the depth of energy renovations and the climate.

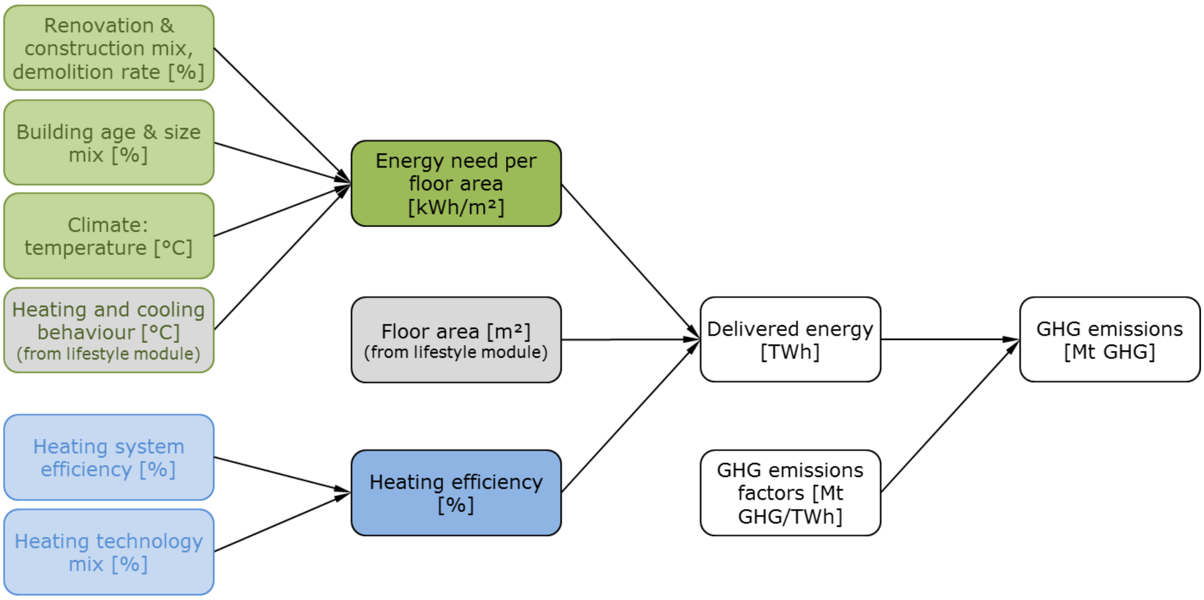

Figure 2: Approach for the calculation of greenhouse gas emissions from buildings

The data sources for the building module are the Building Stock Observatory,[22] Odyssee[23] for buildings stock data and the EU Projects ENTRANZE,[24] Mapping and Analyses of the current and future (2020–2030) heating/cooling fuel deployment (fossil/renewables),[25] and Heat Roadmap Europe for energy data for national building stocks.

The building module is integrated into the EUCalc and receives and delivers data in interaction with other modules. It receives input from the lifestyle module, for example, on the residential floor area development. It receives input from the climate module, for example, on the development of external temperatures.

[19] Here floor area is the conditioned floor area, meaning heated or cooled space.
[20] The development of the energy need depends on the heating and cooling behaviour, which is a consequence of building automation, control and smart systems.
[21] The reduction of indirect emissions from materials, for example through the material switch from steel and concrete to wood, is covered in the manufacturing module.
[22] ec.europa.eu/energy/en/topics/energy-efficiency/energy-performance-of-buildings/eubuildings
[23] www.indicators.odyssee-mure.eu/energy-efficiency-database.html
[24] www.entranze.eu/
[25] Mapping and analyses of the current and future (2020 - 2030) heating/cooling fuel deployment (fossil/renewables);Tender ENER/C2/2014-641, available at ec.europa.eu/energy/en/studies/mapping-and-analyses-current-and-future-2020-2030-heatingcooling-fuel-deployment

Outputs from the buildings module to other modules include the electricity demand that needs to be delivered by the power module, the constructed and renovated areas to industry and to the minerals module, and emissions to the emission module.

The EUCalc building module does not cover emissions from the electricity used in the building sector, because these emissions occur in the energy sector and are calculated by the power module. Electricity generation and district heating generation are linked through combined heat and power (CHP) plants, which are included in the power module. To display the complete CO_2 emissions of buildings the emissions from the generation of electricity and heat supplied to buildings would need to be isolated from the total emissions in the energy sector. The electricity demand covered in the building module, includes lighting, cooling, cooking and also appliances that are used in buildings, for example, fridges and washing machines.

For the purpose of this briefing, the levers of the power module are kept constant at level 1. As the model was not yet working with full interaction at the moment of writing this briefing, the CO_2 emissions from the electricity and the district heating databases could not be included, so these constant assumptions do not have any impact on the results presented below. These components will become operational at a later stage and this briefing will be updated to reflect the possibilities offered from a fully functioning EUCalc model.

4.4 How the building module of the EUCalc Model is used for this report

This briefing is based on the analysis of pathways for GHG emissions in the buildings sector up to 2050; figure 3 visualises its scope. These pathways have been generated by using the EUCalc building module only and keeping all inputs from other modules at level 1.

Parameters such as population development and total floor area demand (from the lifestyle module) have been kept at level 1 for the purpose of this briefing because they cannot directly be influenced by national policymakers when developing their LTRS, but can be considered as an external factor.

Other inputs like the analysis of primary energy emissions for electricity and for district heating, the aggregation of GHG emissions, or choices relative to the climate scenarios were not available as the EU Calc model was not fully functional at the time of writing. These will, however, be available when the EUCalc model is fully operational and will be taken into account when updating this briefing.

The EUCalc building module also includes energy for appliances, but energy used by appliances has been excluded for the purpose of this briefing. This is because the EPBD does not cover the energy used by household appliances,[26] so this is not relevant for creating decarbonisation pathways that mirror LTRS.

[26] Energy efficiency of appliances is regulated by Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products.

As the EPBD does not cover emissions resulting from the production of buildings materials, nor are these covered by the EUCalc building module, these are out of the scope of this briefing.

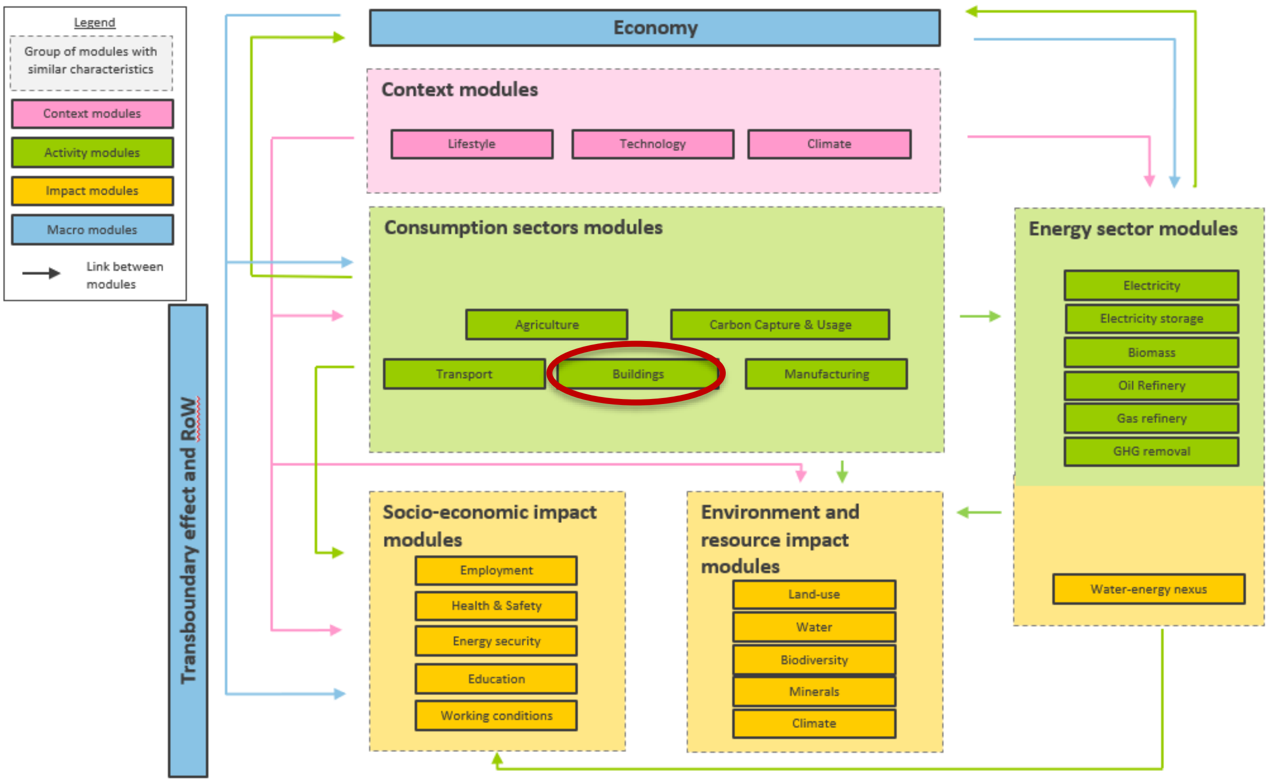

Figure 3: Visualisation of the scope of the briefing

For this briefing we created three pathways. In each pathway all levers are set to the same level. With the EUCalc it is possible to create several additional pathways by mixing the levels of ambition of the different levers.

This briefing presents the impacts resulting from changing the ambition of selected levers of the building module at level 1, level 3 and level 4. We did not create a pathway in which all levers are set at level 2 because such a pathway would fall too short of mirroring a decarbonised building stock in line with EPBD requirements. Annex I summarises the scope of the three pathways.

5 Using EUCalc to support the drafting and analysis of national long-term renovation strategies

In this briefing, EUCalc is used to create GHG emissions reduction pathways in the buildings sector that try to mirror LTRSs in line with the EPBD. We analyse what this could mean in term of impacts for selected Member States and for achieving the EU 32.5% energy efficiency target by 2030.

5.1 Modelling 2050 objectives: EU results

Within the framework of the modelling assumptions explained in the previous section, EUCalc can be used to model different pathways for reducing CO_2 emissions of the buildings sector up to 2050 for the EU as a whole.

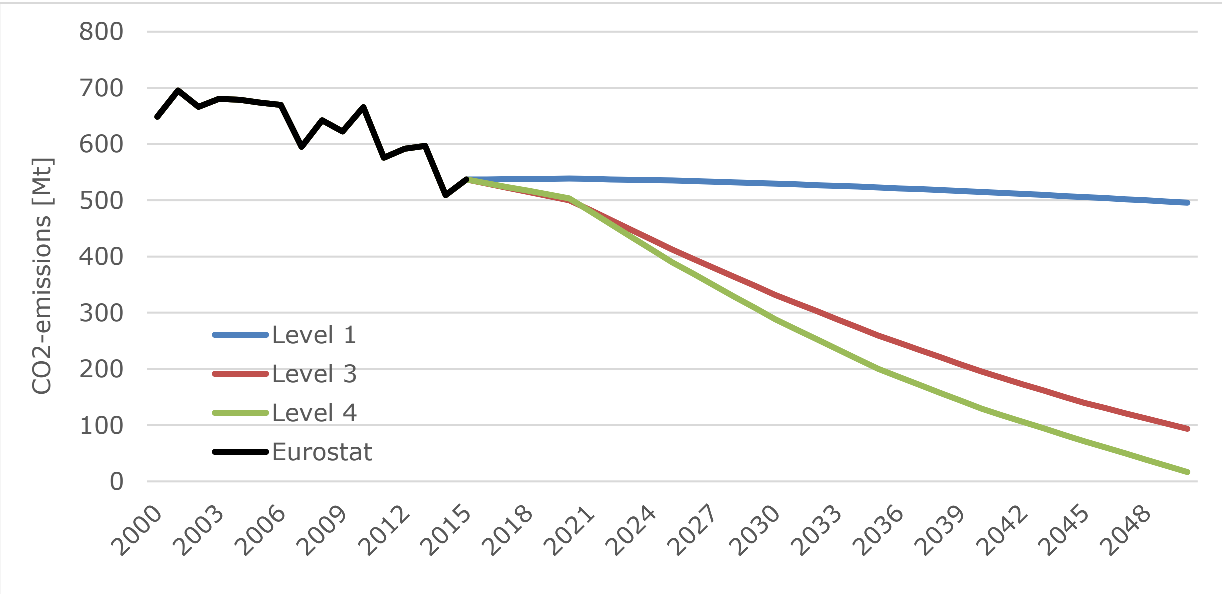

Figure 4: CO_2 emissions for the EU28 following decarbonisation ambition level 1, 3 and 4 in buildings

The pathway level 1 (“observed trends continuation”) shows a decrease of buildings’ CO_2 emissions of 8% compared to 2015,[27] while the level 3 and level 4 scenarios result in a reduction of emissions of 83% and 97% respectively.

The level 3 pathway is in line with ambitious but realistic current technologies and practices that, while not mainstream, are already applied in Europe. Level 4 demands transformational change in current demolition, construction and renovation practices to achieve an almost total decarbonisation of the demand and supply of heat in buildings.

This most ambitious pathway can be considered consistent with the legal obligation of the EPBD that requires Member States to develop LTRSs that achieve a decarbonised building stock by 2050. EUCalc gives an indication of the scale of the impacts Member States need to achieve to comply with this obligation and the transformative effects that LTRS policies and measures would require. The level 4 pathway assumes a renovation rate of 3%, leading to a refurbishment of all existing buildings by 2050; out of these renovations, the great majority are assumed to be deep renovations with no shallow refurbishment. Also, level 4 assumes a demolition rate of 1%, which would mean about 37% of existing buildings will be demolished and replaced by new nearly zero-energy buildings by 2050.

5.2 Modelling 2050 objectives: national results

As EUCalc is able to model country-specific pathways for all 28 Member States and Switzerland, it can also be used to draw indicative national pathways towards a decarbonised building stock by 2050 in line EPBD obligations. Member States could use the tool to inform the drafting of their LTRSs, due by 10 March 2020. It can also be a useful resource for the European Commission to get an indication of how Member States' LTRSs comply with the 2050 decarbonisation objective.

It is worth noting again that this briefing is based on the EUCalc building module, which only includes levers for heating efficiency and heating mix. Levers on PV penetration or fossil fuel phase-out in electricity production are covered by the power sector module. For this reason, a comprehensive analysis of Member States' pathways towards a fully decarbonised building stock, reached both with a reduction of energy consumption through energy efficiency measures and decarbonisation of the remaining energy needs through renewable energy sources (both heat and power), would require a combination of the two modules. This will be presented in an update of this paper.

The following section illustrates some potential national results and presents pathways to achieving decarbonisation of demand and heating in buildings for selected countries (Annex II provides an example of pathways for additional countries).

GERMANY

For Germany, the level 1 pathway would result in a decrease of CO_2 emissions of 8%, level 3 of 72% and level 4 of 97% compared to 2015, as shown in figure 5 below.

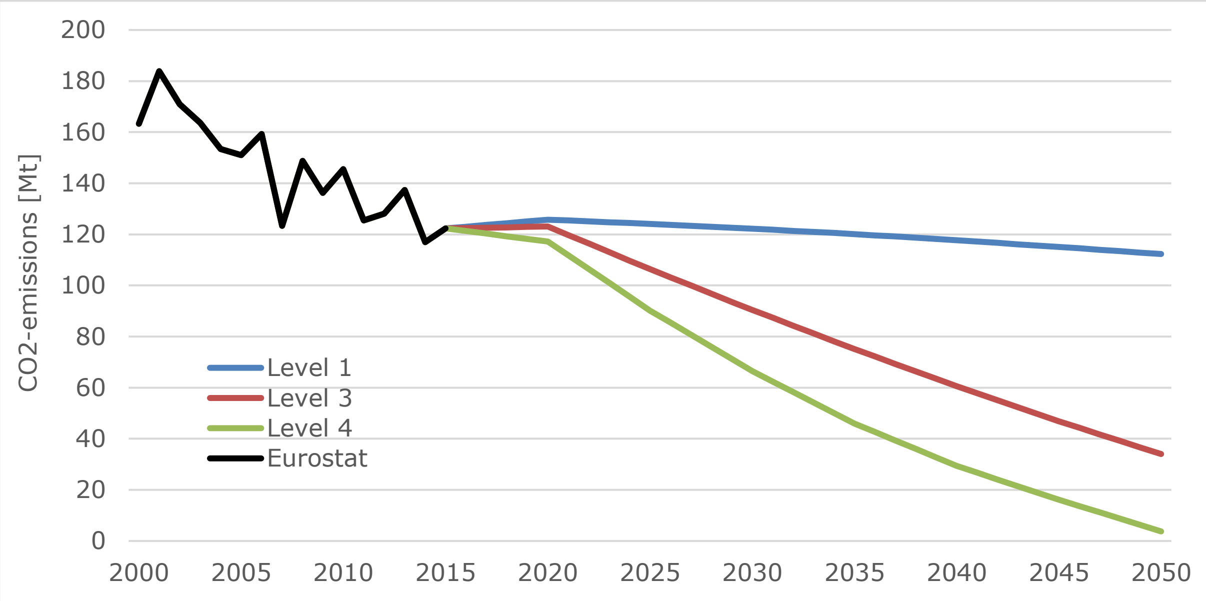

Figure 5: CO_2 emissions for Germany following decarbonisation ambition level 1, 3 and 4 in buildings

FINLAND

For Finland, the level 1 pathway would result in a decrease of CO_2 emissions of 21%, level 3 of 81% and level 4 of 98% compared to 2015.

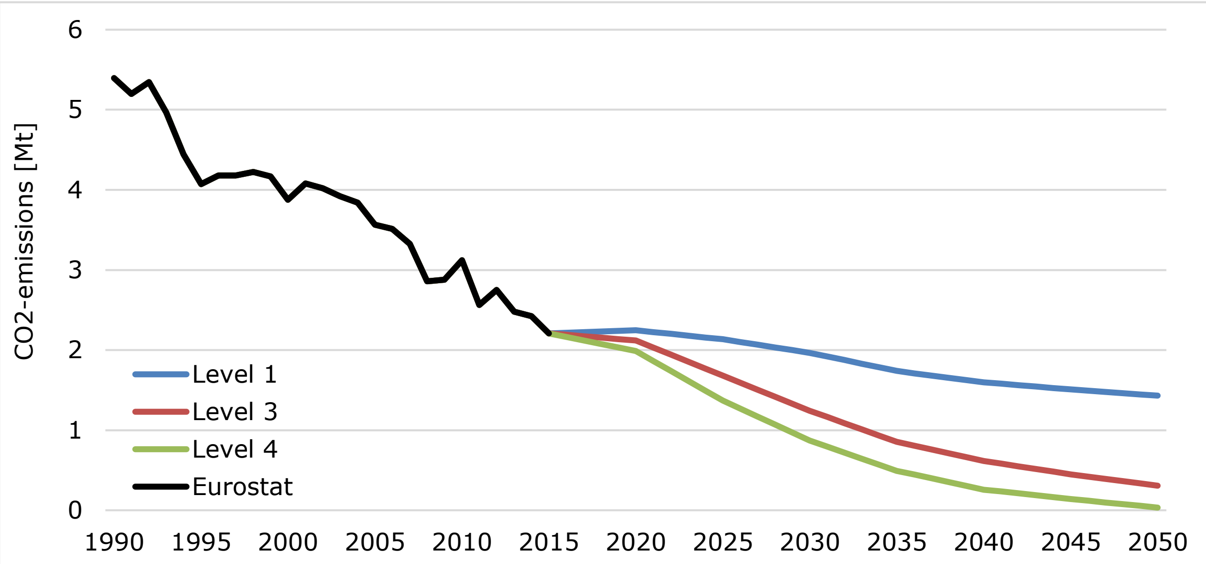

Figure 6: CO_2 emissions for Finland following decarbonisation ambition level 1, 3 and 4 in buildings

POLAND

For Poland, level 1 would result in a decrease of CO_2 emissions of 39%, level 3 of 91% and level 4 of 98% compared to 2015.

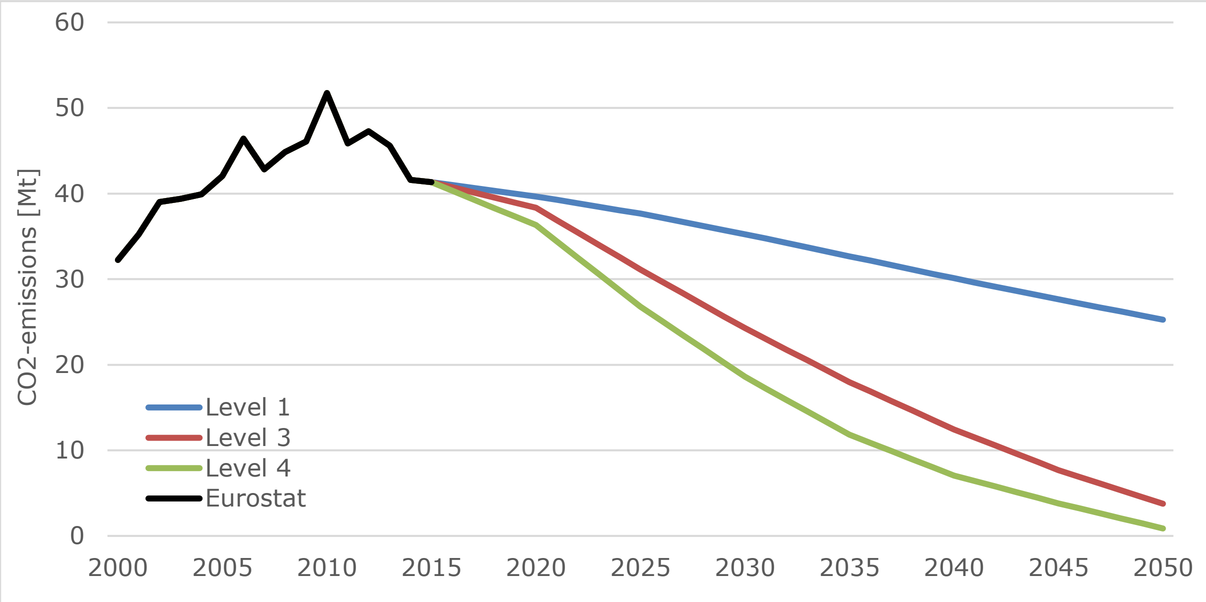

Figure 7: CO_2 emissions for Poland following decarbonisation ambition level 1, 3 and 4 in buildings

The above examples give an indication that if Member States implement very ambitious, but realistic, practices and technologies for reducing energy consumption in buildings (in line with the level 3 pathway), a substantial reduction of GHG emissions could happen by 2050. For Poland, for example, the implementation of measures in line with level 3 could already reduce CO_2 emissions by 91% compared to 2015.

If Member States embarked on large-scale additional efforts based on major technological advances and breakthroughs (in line with the level 4 pathway) this could lead to almost complete decarbonisation of energy demand and heat in buildings by 2050 – a reduction of 97% of CO_2 emissions for Germany and of 98% for Poland and Finland. This implies following a pathway that will completely transform the current practices of today’s buildings sector, as these pathways are based on ambitious assumptions, such as, for example, increasing the renovation rate to 3% per year and the demolition rate to 1% per year.

5.3 Modelling 2030 milestones

As explained in Section 3.1, when Member States draft their LTRSs, they must also establish intermediate milestones for 2030, 2040 and 2050 that will contribute to the achievement of the 2050 decarbonisation goal. When EUCalc is used to generate indicative country-specific pathways leading to a decarbonised building stock by 2050, as shown in the previous section, it can also be a useful tool to investigate how the intermediate milestones for 2030 could look.

For example, out of the non-exhaustive list of milestones included by the European Commission in its guidance note, EUCalc could be used to model the percentage of renovated buildings and the percentage of highly efficient buildings.

The section below provides illustrative examples for Croatia and France on how EUCalc can be used to model selected 2030 milestones.

For Croatia, the following graphs show the amounts of renovated buildings according to the depth of renovation (shallow, medium and deep) and the amount of new builds out of the total heated floor area for the level 1, level 3 and level 4 pathways. The pie charts show the composition of floor area in 2030 according to the different pathways. For the level 4 pathway only 27% of buildings are still unrenovated in 2030, compared to 72% for level 1; 33% of buildings will have been deep renovated and 14% have undergone medium renovations, with no shallow renovations. These figures give an idea of the milestones Croatia might want to set up when developing its LTRS in line with a decarbonised building stock by 2050.

CROATIA

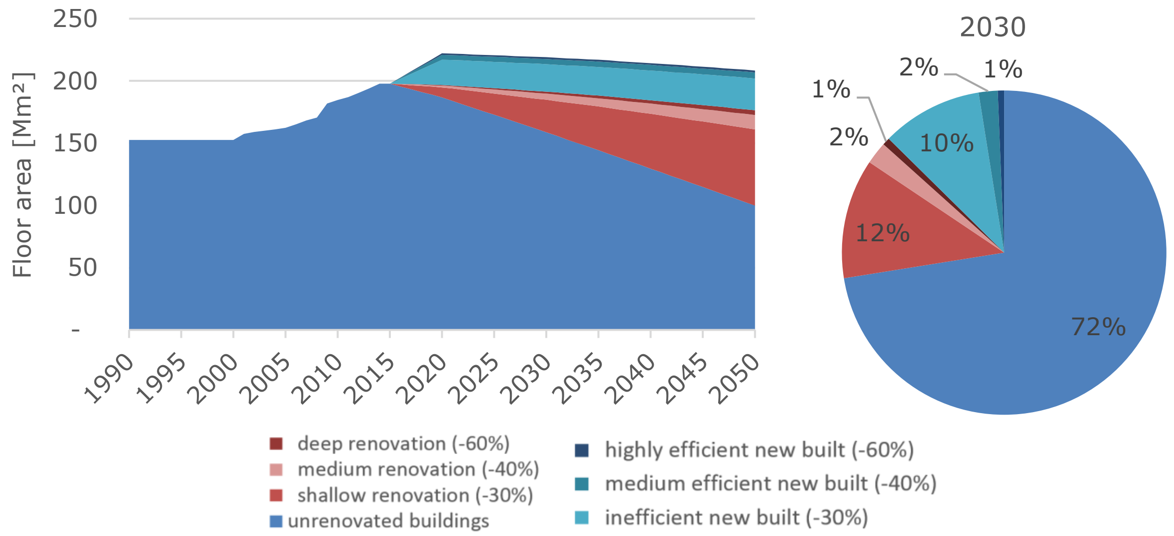

Figure 8: Floor area development due to renovation and new construction and their percentage of the stock in 2030 according to level 1 pathway (Croatia)

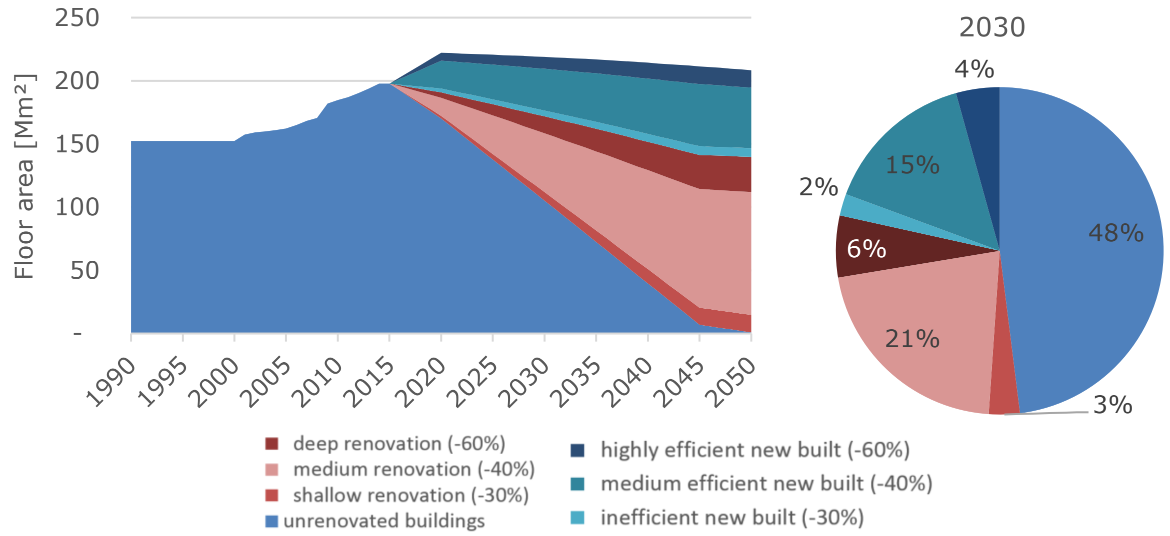

Figure 9: Floor area development due to renovation and new construction and their percentage of the stock in 2030 according to level 3 pathway (Croatia)

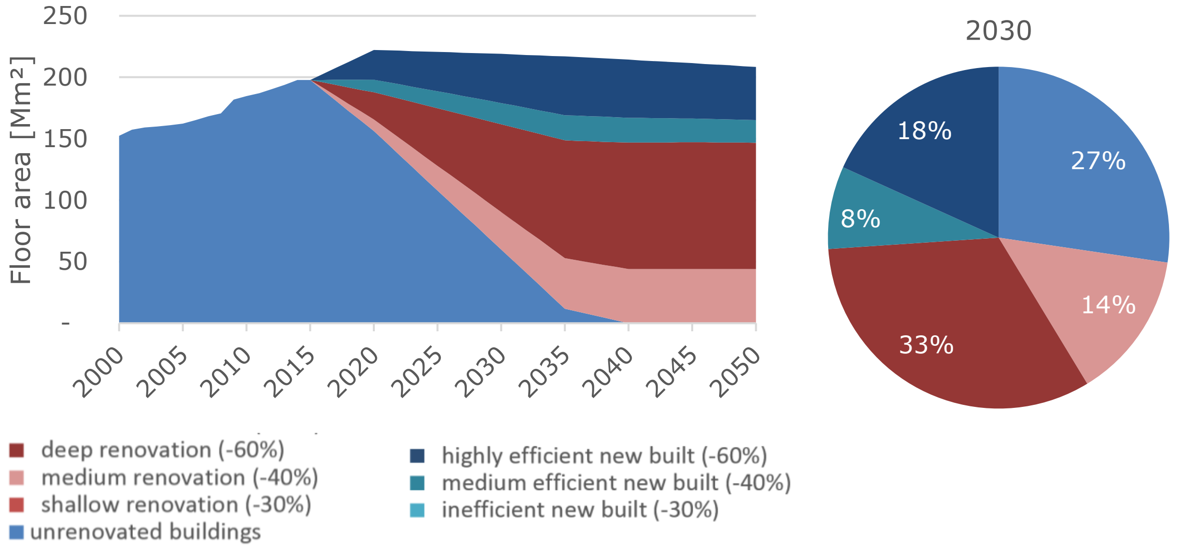

Figure 10: Floor area development due to renovation and new construction and their percentage of the stock in 2030 according to level 4 pathway (Croatia)

For France, the following graphs show the composition of the floor area in 2030 according to pathways that model different level of ambition. In 2030, for the level 4 pathway, 35% of buildings are still unrenovated; 32% have undergone deep renovation and 14% medium-depth renovations, with no shallow renovations. These figures give an idea of the milestones France might want to set up for 2030 when developing its LTRS in line with a decarbonised buildings stock by 2050.

FRANCE

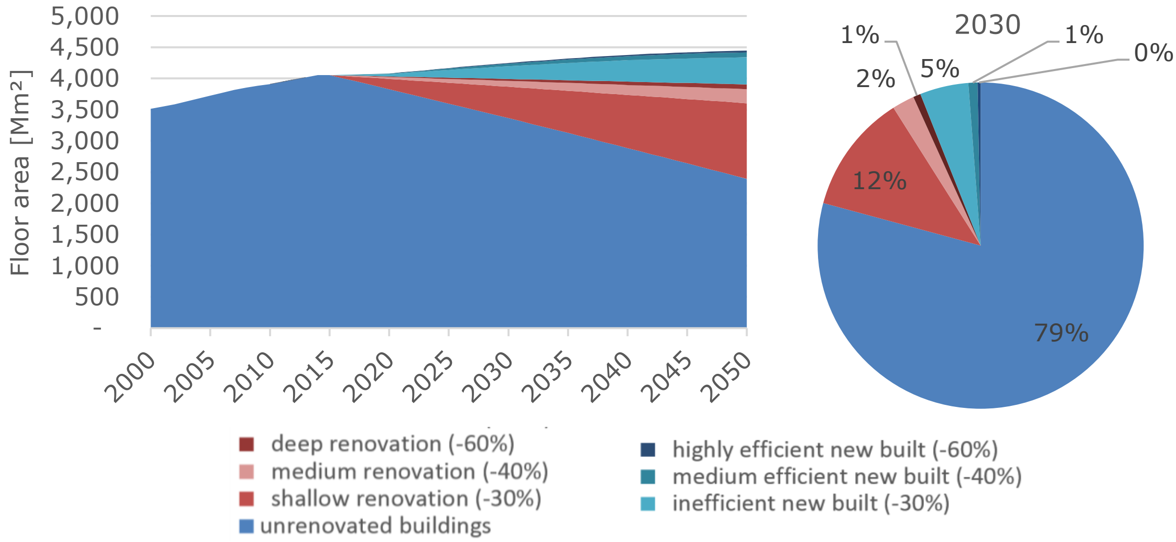

Figure 11: Floor area development due to renovation and new construction and their percentage of the stock in 2030 according to level 1 pathway (France)

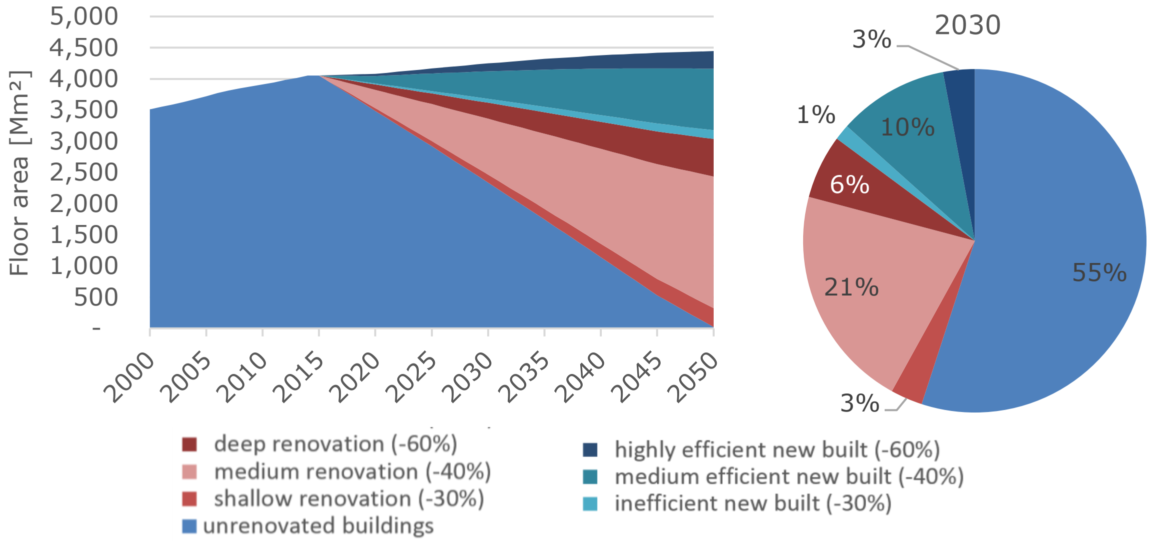

Figure 12: Floor area development due to renovation and new construction and their percentage of the stock in 2030 according to level 3 pathway (France)

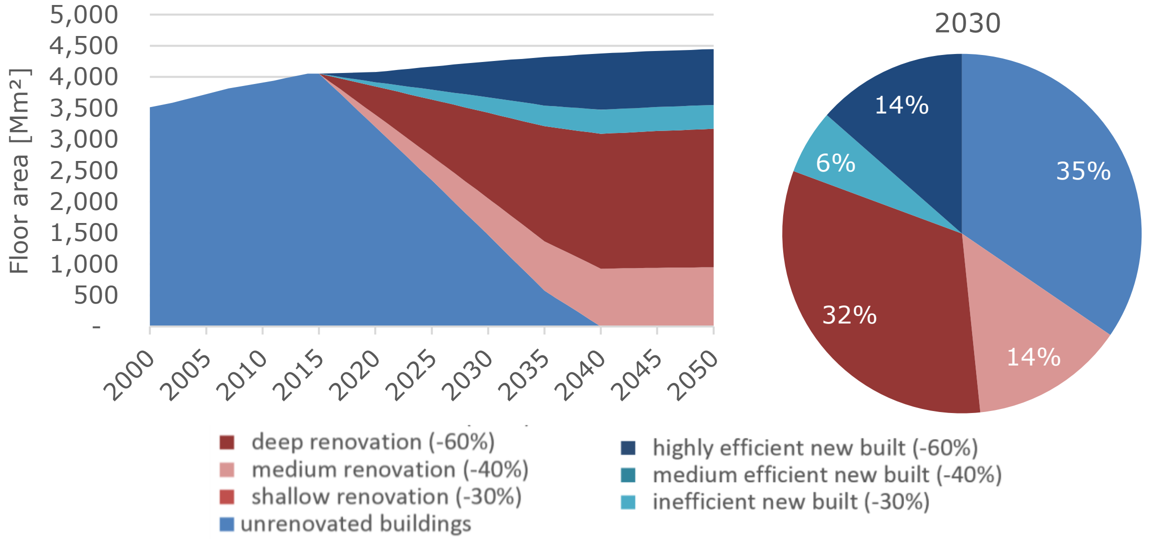

Figure 13: Floor area development due to renovation and new construction and their percentage of the stock in 2030 according to the level 4 pathway (France)

5.4 Using EUCalc for modelling buildings' contribution to the 2030 energy efficiency target

According to the EPBD, indicative LTRS milestones for 2030, 2040 and 2050 must contribute to the European Union 2030 energy efficiency target and Member States must specify how.

The 2030 EU energy efficiency target of at least 32.5% is a reduction in primary and/or final energy consumption compared to energy projections. It translates into a maximum energy consumption for the EU of no more than 1,273 Mtoe of primary energy and/or no more than 956 Mtoe of final energy in 2030.

EUCalc can provide an indication of how the aggregated 2030 milestones for the EU28 could contribute to the achievement of this target. To do so, this section compares the EU energy efficiency target and the EUCalc pathways that try to mirror LTRSs, constructed as explained in section 4.4. The figure below the final energy demand for the three pathways previously outlined.

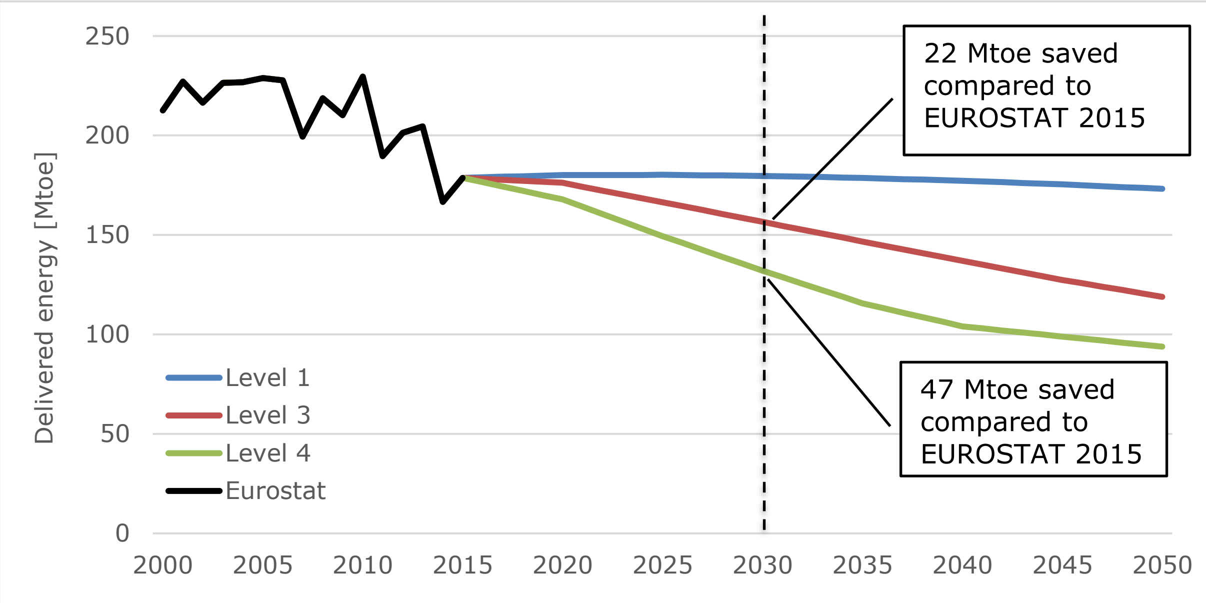

Figure 14: Final energy demand for the level 1, 3 and 4 pathways

First, the 2030 EU energy efficiency target (no more than 956 Mtoe of final energy in 2030) has been expressed in terms of energy savings compared to 2015 Eurostat data of final energy consumption, which is 1088 Mtoe.[28] This means that the 2030 EU energy efficiency target, for the purpose of our comparison, is expressed as energy savings of 132 Mtoe.[29]

Next, we used the pathways in the EUCalc building module to calculate an aggregated final energy consumption in 2030 for the EU28 of 180 Mtoe for level 1, 157 Mtoe for level 3 and 132 Mtoe for level 4. Comparing these with 2015 Eurostat data gives energy savings of 22 Mtoe for level 3 and 47 Mtoe of level 4 in 2030.

Finally, those figures are compared to show the possible contribution of aggregated 2030 milestones, in line with level 3 and level 4 pathways, to the 2030 EU energy efficiency target.

[28] https://ec.europa.eu/eurostat/databrowser/view/t2020_34/default/table?lang=en
[29] If the latest 2017 Eurostat data were to be used for this briefing, the total energy savings would amount to 166 Mtoes as final energy consumption in the EU in 2017 was higher than in 2015.

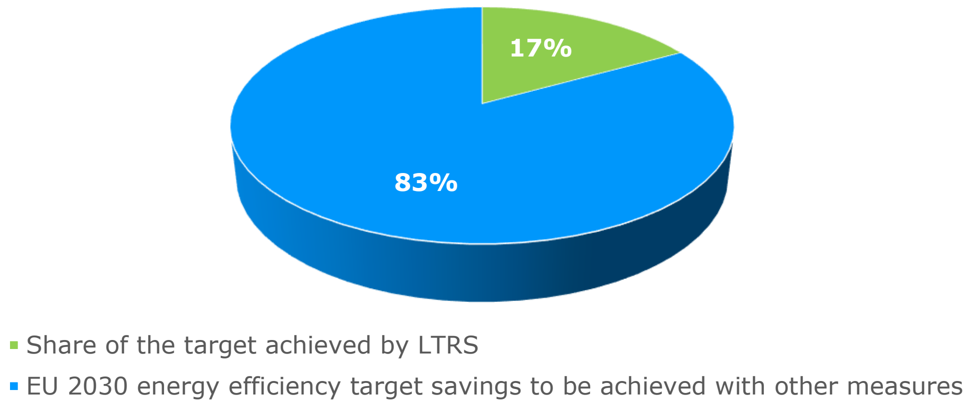

Figure 15: Contribution to EU 2030 energy efficiency target of 2030 milestones with the level 3 pathway

The pie charts above give an indication of the potential contribution to the 2030 EU energy efficiency target of reducing demand through envelope improvement and switching to efficient heat in the building sector. If Member States adopt policies in line with the level 3 pathway, and plan intermediate milestones for 2030 accordingly, efficiency measures to reduce demand and supply of heat in buildings could contribute around 17% of the 2030 energy efficiency target expressed in final energy savings (figure 15).

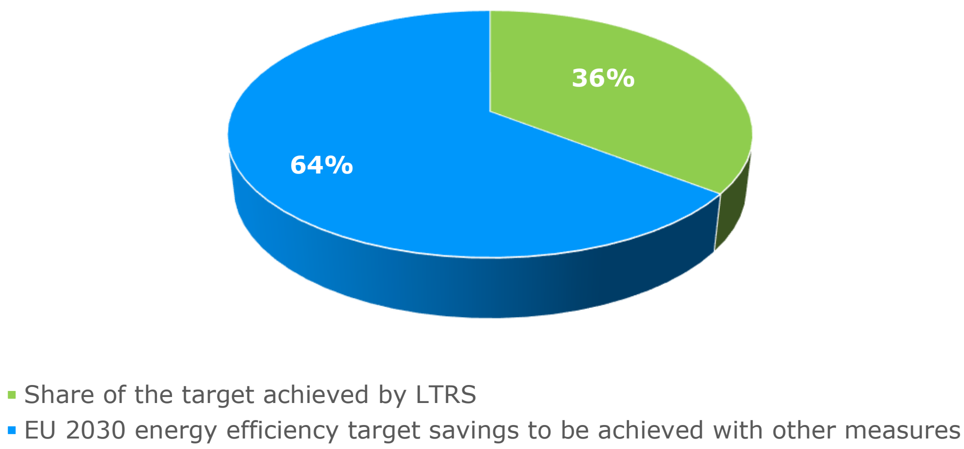

Figure 16: Contribution to EU 2030 energy efficiency target of 2030 milestones with level 4 pathway

If Member States adopt and implement LTRSs that achieve the 2050 decarbonisation objective (in line with the level 4 pathway), and plan intermediate milestones for 2030 accordingly, these measures could contribute around 36% of the 2030 energy efficiency target (figure 16).

It is clear that if Member States plan measures to achieve a decarbonised building stock by 2050, and then back-cast 2030 milestones accordingly, the LTRS could largely contribute to the 2030 EU energy efficiency target.

6 Policy implications[30]

When Member States draft and implement LTRSs that are in line with the requirements of the EPBD, they must put in place policies and measures that lead to a transformation of the building sector compared to today.

For example, the level 4 pathway, which can be considered consistent with the EPBD LTRS requirements of achieving a highly energy efficient and decarbonised building stock by 2050, assumes a renovation rate of 3% leading to a refurbishment of all existing buildings by 2050. Out of these renovations, the great majority are assumed to be deep renovations with no shallow refurbishment. The demolition rate is about 1% per year.

To achieve a similar level of impacts, Member States must use the drafting of their LTRS as an occasion to rethink their policy interventions in the buildings sector and put in place a coherent strategy that mobilises resources and actors towards the long-term decarbonisation goal. The first step in that direction is for Member States to construct their LTRS around this long-term goal and to plan the appropriate policies and measures to achieve it. In addition, they must also plan short-term measures that are consistent with this long-term goal. If the goal of achieving a highly energy efficient and decarbonised building stock is not integrated correctly in the planning, the LTRS risks being a patchwork of conventional measures that will not deliver the changes in the sector at the scale needed. On the contrary, new innovative policies need to be mainstreamed across the EU.

Member States have at their disposal a broad range of policy instruments, which must be tailored to the national situation and different starting point of every country. An increase in the renovation rate of existing buildings from the current 1% to 3% would require the adoption and mainstreaming of policy measures such as minimum energy performance requirements for existing buildings (e.g. when a building is sold or rented[31]) or advisory tools like one-stop-shops to help citizens in their renovation journey. It would also require industrialised and prefabricated renovation solutions, on the model of the Dutch Energiesprong,[32] which would reduce costs of deep renovations and increase their rate. Achieving an increased renovation rate would also require large mobilisation of investment, especially to support the renovation of residential buildings.[33]

Increased demolition also plays a role in the most ambitious pathway modelled, with a demolition rate assumed to increase from 0.1% to 1%. This means that some of the worst-performing buildings, which are more costly to renovate than to rebuild, would be demolished. Any demolition strategy should be carefully designed by prioritising commercial buildings that already have a shorter lifespan and a higher demolition rate than residential buildings. It must also take into account circular economy principles, including the need to reduce construction waste.

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[30] The policy implications presented in this briefing are not a direct output, nor a direct result, of the EUCalc model.
[31] bpie.eu/publication/renovation-in-practice
[32] energiesprong.org/country/the-netherlands
[33] See as well the European Investment Bank draft energy lending policy available at www.eib.org/attachments/draft-energy-lending-policy-26-07-19-en.pdf

Additionally, a much more integrated planning approach that captures the inter-dependencies between supply and demand in the building sector is crucial for its decarbonisation. The deployment of renewable heat technologies, like the latest generation district heating and cooling systems or heat pumps, is more effective with very low energy buildings. Combining the planning of renovations in both buildings and heating systems can effectively avoid unnecessary investments and lock-in effects. LTRSs should capture and plan how to maximise these synergies.

The briefing also shows that if Member States draft LTRSs with a clear 2050 de-carbonisation goal in mind and then back-cast 2030 milestones, these alone could contribute 36% of the EU 2030 energy efficiency target. With this level of ambition in LTRSs, Member States' aggregated national energy efficiency contributions would be likely to overachieve the 32.5% energy efficiency target, instead of falling short by up to 6%.

To conclude, this briefing demonstrates that decarbonising the building stock is a societal challenge that will require wide socio-economic transformation. Achieving the level of impacts in line with the most ambitious pathway will require acceptance and support from a wide spectrum of stakeholders, from local authorities to the construction industry, to civil society organisations, to installers and builders. Only with shared ownership of the long-term objective will there be better acceptance of the measures to achieve it. This means that any successful LTRS must be based on an inclusive consultation process to gather opinion and advice from different stakeholders and to clearly present the challenges and opportunities of the process ahead.

7 Conclusions

This briefing shows how the EUCalc model can be used to develop pathways for reducing GHG emissions that mirror EU and national policies. In particular, it creates and explores the impacts and implications of three pathways that potentially reflect the national LTRSs, which Member States are required to submit to the European Commission by 10 March 2020 in compliance with the EPBD. It concludes that large additional effort and major technological advances and breakthroughs compared to the buildings sector's current construction and renovation practices are possible and necessary if Member States are serious in drafting roadmaps that will lead to a highly energy efficient and decarbonised building stock by 2050. If LTRSs are drafted with this ambition in mind, they will also make a significant contribution to the achievement of the 2030 energy efficiency target and will be the driver for accelerating actions by 2030.

8 Annex I Summary of the scope for this briefing

Table 3: Scope of the EUCalc model, of the building module and of this paper

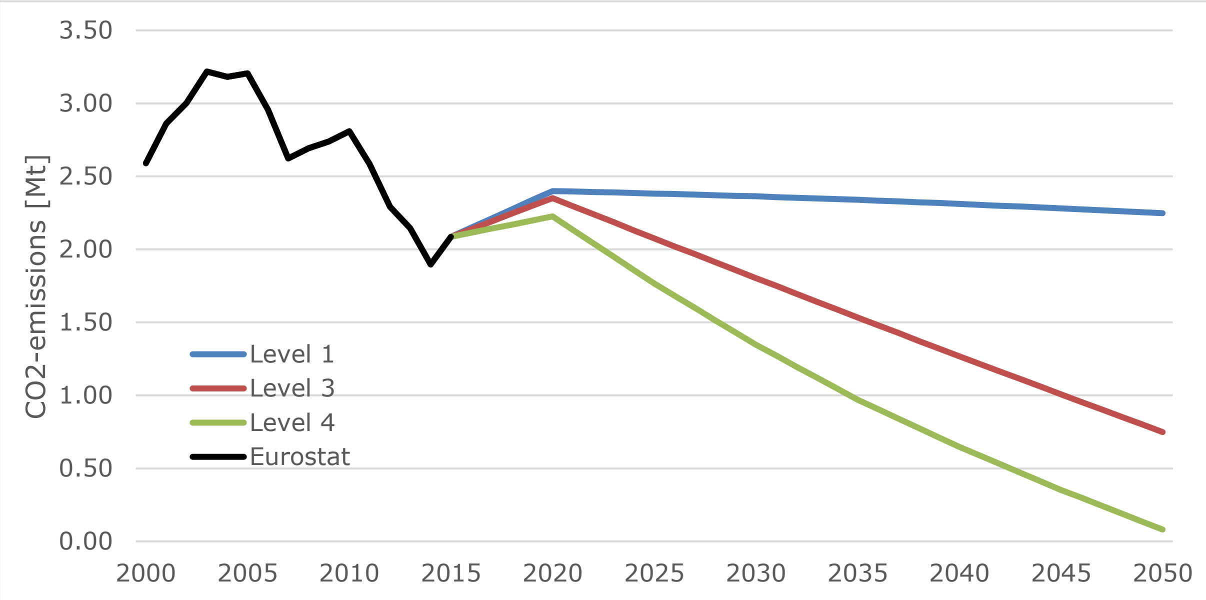
Building sector input sections and results scope	Where is it covered in the EUCalc model?	Is it covered in the building module?	Is it covered in this report?
Building sector inputs			
Residential buildings		Yes	Yes
Single-family homes			
Multi-family homes		Yes	Yes
Non-residential buildings		Yes	Yes
Offices			
Educational buildings		Yes	Yes
Health buildings		Yes	Yes
Trade and wholesale		Yes	Yes
Hotels and restaurants		Yes	Yes
Other		Yes	Yes
Energy uses			
Space heating		Yes	Focus: yes
Space cooling		Yes	Not in focus
Lighting		Yes	Not in focus
Cooking		Yes	Not in focus
Appliances		Yes	Not in focus
Energy carriers/ Technologies			
Gas	Building module	Yes	Yes
Oil	Building module	Yes	Yes
Coal	Building module	Yes	Yes
Electricity	Building module	Yes	Yes
CHP	Power module	No	No
Waste heat from industry	Industry	No	No
Result coverage			
Cost	Cost module Power module: fuel cost	Yes,partly: investments	No
CO_2 emissions for heating	Building module	Yes	Yes
CO_2 emissions for electricity	Power module	No	No, at the time of writing this report the EUCalc model was not running, hence the report includes only results from the building module.
CO_2 emissions for district heating	Power module	No	
Primary energy	Power module	No	
GHG emissions	Climate module	No	
Material substitution	Manufacturing module	No	

9 Annex II Additional countries' CO_2 emissions

This annex presents pathways to achieving decarbonisation of demand and heating in buildings for Croatia, France and Spain.

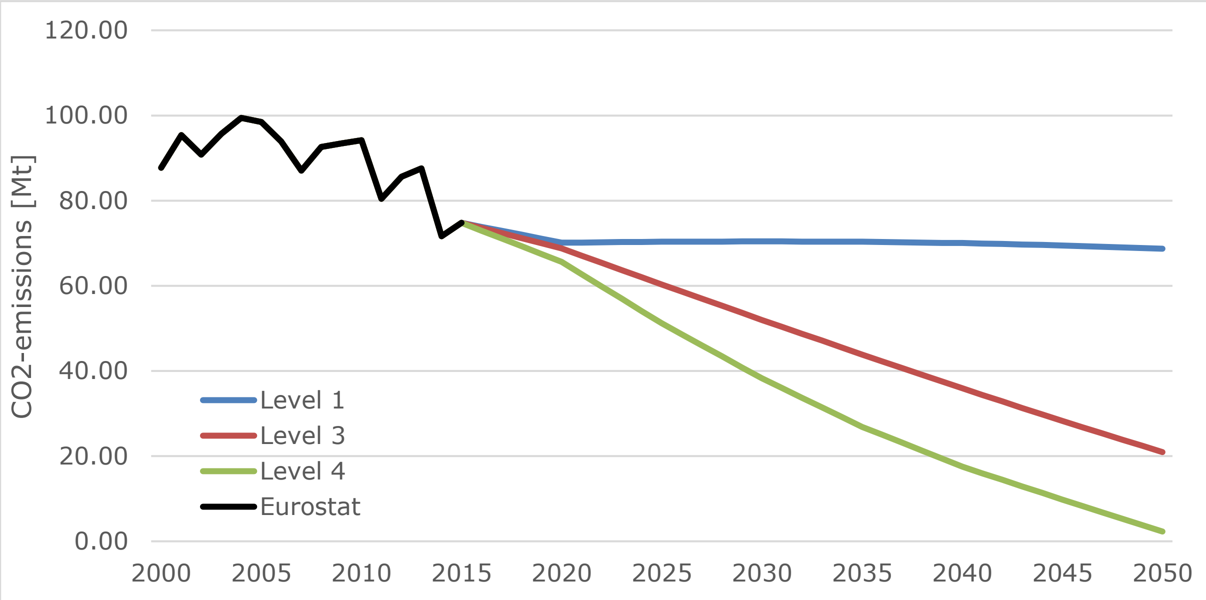
Croatia

For Croatia, the level 1 pathway would result in a decrease of CO_2 emissions of 8%, level 3 of 64% and level 4 of 96% compared to 2015.



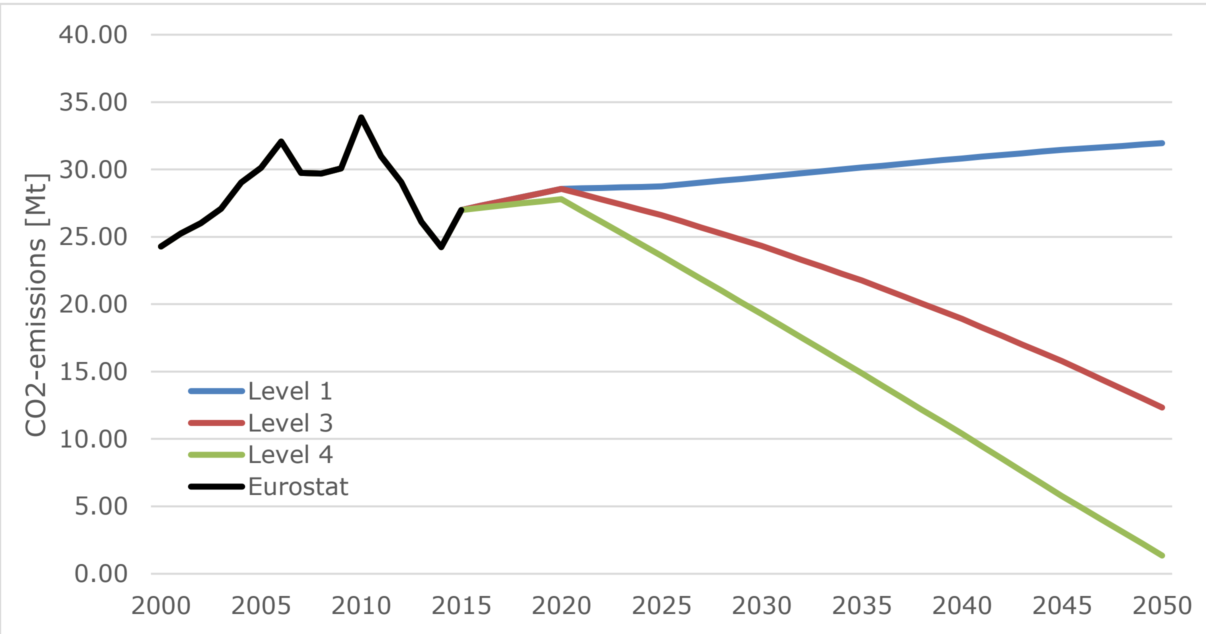
France

For France, the level 1 pathway would result in a decrease of CO_2 emissions of 8%, level 3 of 72% and level 4 of 97% compared to 2015.



Spain

For Spain, the level 1 pathway would result in an increase of CO_2 emissions of 18%, compared to a decrease of 54% for level 3 and 95% for level 4 compared to 2015 emissions.



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