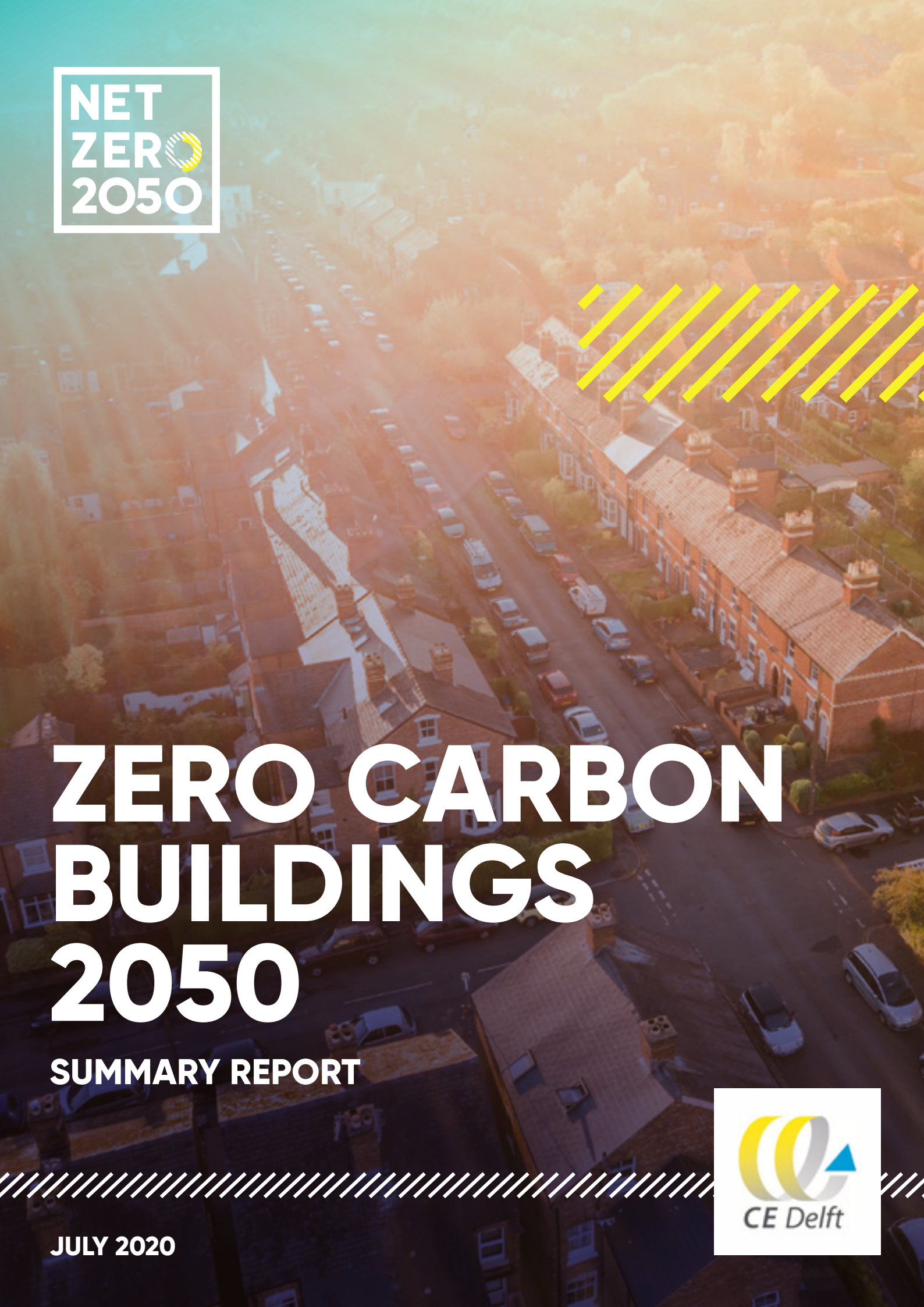

NET ZERO 2050

ZERO CARBON BUILDINGS 2050

SUMMARY REPORT

CE Delft

JULY 2020

ACKNOWLEDGEMENTS

This report is the outcome of a six-month long endeavour of deep analytical work conducted by CE Delft, with support from Climact. Its aim is to highlight the importance and urgency of decarbonising the building sector in order to achieve net-zero economy targets in line with the EU's commitment under the 2015 Paris Agreement. It assesses the policies and innovation needed to achieve a fully decarbonised EU residential building sector by 2050, making the case for new policies targeting the sector at the EU, national and local levels. The researchers have not undertaken new modelling, but instead used existing modelling results (as found in the 2019 ECF report "Towards Fossil Free Energy in 2050") as the basis for the development of a policy and innovation roadmap that takes an integrated perspective on the residential building sector.

This report was prepared by:

CE Delft:
Katja Kruit, Joeri Vendrik, Pien van Berkel, Fenneke van der Poll, Frans Rooijers

Climact (modelling):
Quentin Jossen, Hugues de Meulemeester

Project coordination (European Climate Foundation):
Renée Bruel, Stijn Carton, Adeline Rochet, Ting Zhang

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NET ZERO 2050

DISCLAIMER

This report commissioned by the European Climate Foundation (ECF) as part of the Net-Zero 2050 series, an initiative of the ECF with contributions from a consortium of experts and organisations. The series aims to build a vision and evidence for the transition to net-zero emission societies in Europe and beyond by mid-century at the latest, in line with the Paris Agreement objectives. The ECF is funded solely by private philanthropic organisations and does not have any financial ties to EU political bodies or to private entities.

For more information, please contact:
ting.zhang@europeanclimate.org

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EXECUTIVE SUMMARY

The Paris Agreement commits countries around the world to limiting global warming to well below 2°C above pre-industrial levels, with an aspiration target of limiting the temperature increase to 1.5°C. The cost of failing to reach these targets would be catastrophic, and considerably higher than the investment needed to deliver them. The EU must fully decarbonise its economy by 2050 in order to fulfil its commitment to the Paris Agreement objectives. This requires bold action across all sectors, and in none more than buildings.

Energy use in buildings currently accounts for 36% of greenhouse gas (GHG) emissions in the EU (European Commission, 2019) making buildings one of the largest contributors to EU GHG emissions. In its long-term strategy for 2050 (2018), the European Commission recognises the need for a near-complete decarbonisation of the EU's building sector to meet its climate goals. At the same time, European citizens have a lot to gain from the decarbonisation of buildings, including employment, health, lower household energy bills and system cost savings (Element Energy & Cambridge Econometrics, 2019).

Despite the necessity, benefits and urgency of decarbonising buildings, it is one of the sectors that has arguably seen the least progress to date. With over 513.5 million stakeholders[1], whose lives and behaviour are directly impacted by changes related to buildings, it is notoriously difficult to implement policies to decarbonise the sector.

1 Population of EU-28 on 1 January 2019 (https://ec.europa.eu/eurostat/statistics-explained/index.php/Population_and_population_change_statistics#EU-28_population_continues_to_grow)

The momentum and opportunities for rapid emissions reduction are there. Europe is setting out to implement the European Green Deal, starting up its Renovation Wave, revising key Directives as well as seeking to recover from the largest health and economic crisis of the last century. To help policy-makers at different levels in Europe capture this momentum, this report recommends a first-ever long-term roadmap of policies to deliver essential carbon reductions in the residential building sector.

The report finds that there are three key areas to target in order to set the sector on a trajectory to zero emissions. These are: **reducing energy demand through renovation of the building stock, shifting to zero-carbon energy carriers, and applying the principles of circularity to the building supply chain.** Each of these areas will require policy-makers to introduce a combination of new regulatory and pricing policies. The need for these policies is urgent to put Europe on the right track, as there are very limited renovation windows left before 2050. The figure on Page 7 provides an outline for a policy package that will put the building sector on a trajectory to zero emissions.

MAIN POLICY MESSAGES

Current policies focusing on incentives and information are not enough to achieve full decarbonisation of the residential building sector. Additional **regulatory and pricing policies** as well as instruments that support the **deployment of innovation** are needed to reach the full emission reduction potential.

The areas that have the largest GHG emission reduction potential are:

- Reducing energy demand by improving the energy performance of the existing building envelope
- Switching to zero-carbon fuels for heating, including a switch in heating systems
- Reducing embedded carbon in construction and renovation materials

These are also the areas that lack effective policy measures the most, both at EU and national levels.

A comprehensive policy package, built on the existing regulations, needs to be developed and implemented by the EU and individual Member States. It should at the least contain the following components:

- Minimum energy performance standards for existing buildings that apply at key moments in the building's lifetime, such as sale and change of tenants, or are set at a certain moment in time and subsequently tightened over time
- Regulatory policies to promote heating fuels and appliances switching, such as:
  - A cap on the CO_2 emissions of energy carriers for retail energy suppliers
  - Local or regional heating plans to implement direct electrification of heating and district heating
  - A rapid and equitable transition out of fossil fuel heating systems
  - A ban on the use of fossil fuels for heating and cooking in new constructions
- CO_2-based taxation/pricing of energy carriers for heating (via revision of the Energy Taxation Directive), in combination with a scheme that uses the revenues to support low-carbon measures such as deep renovation, especially targeting low-income households
- Emissions requirements over the life cycle of construction and renovation projects, products and materials
- Supporting policies to facilitate the transition, including financial support to alleviate energy poverty

Full decarbonisation will require a concerted innovation effort. This calls for **targeted tools** to incentivise and deploy innovation, increasing innovation capacity in some areas of the building sector while addressing the fragmentation of the market and creating a demand for innovative solutions.

There is no time to waste in introducing these policies. Because the lifetime of most investments in the building sector is very long, delaying action means passing up key investment moments. Missing this window creates the threat of higher overall costs for society.

A COMPREHENSIVE POLICY PACKAGE TO REDUCE EMISSIONS FROM THE BUILDING SECTOR TO ZERO

POSSIBLE EMISSIONS REDUCTION OF 725Mt

BUILDING ENVELOPE – REGULATORY INSTRUMENTS
Energy performance requirements:
- for owner-occupied buildings (at minimum at sale)
- for rental buildings (new tenants and/or planned renovation)

Embedded emissions

-140 MT

HEATING FUEL SWITCH – REGULATORY INSTRUMENTS
- Cap on carbon emissions of energy carriers
- Local heating plans with obligation for district heating
- Ban on fossil fuels for heating and cooking in new constructions
- Phasing out new fossil fuel heating systems over time

-291 MT

APPLIANCE EFFICIENCY

-81 MT

RENEWABLE ELECTRICITY

-77 MT

MATERIALS – REGULATORY INSTRUMENTS
Lifecycle emission requirements for construction/renovation projects and materials

-135 MT

+ CO_2 PRICING – PRICING INSTRUMENTS

+ SUPPORTING POLICIES – FINANCIAL AND INFORMATION INSTRUMENTS
Financial support to accelerate change and mitigate energy poverty

INTRODUCTION

With over 36% of EU GHG emissions attributed to buildings, efforts to decarbonise the building sector are at the heart of the EU's pledge to achieve a net-zero economy by 2050. But unlike the transition that has been unfolding and gaining speed in the power and transport sectors, change in the building sector has been modest to date.

As part of the European Climate Foundation's (ECF) Net-Zero 2050 series, this report aims to highlight the importance and urgency of decarbonising the building sector in order to achieve net-zero economy targets. Centred around residential buildings, it makes the case for new policies targeting the sector at EU, national and local level, showing the potential of those policies to reduce carbon emissions. The geographical scope of the report is the EU-28[2] and it covers both operational and embedded emissions.

The ECF commissioned CE Delft to analyse the potential for emission reductions, drawing on existing data on current and projected emissions from the building sector, and utilising a zero-emissions scenario developed by Climact using the EU Calc model. Based on these outcomes, a framework was developed for analysing policy needs and gaps. Examples of national policies were pulled from case studies of Poland, Spain and the Netherlands. Finally, innovation needs were identified in consultation with an expert panel. This summary report highlights the key policy messages. The full background report by CE Delft can be found separately online.[3]

The 2020 COVID-19 crisis once more highlights the need for good quality homes, as people are spending a large part of their lives inside. The importance of highly efficient, comfortable homes cannot be underestimated for improving health and quality of life and reducing energy poverty and carbon emissions. Upgrading the quality of the EU building sector is highly labour-intensive. The investment therefore provides employment in times when it is most needed. Developing new and strengthening existing policies in the building sector can provide a stimulus with immediate as well as long-term benefits.

The EU has recognised the economic benefits of investing in green buildings and is embarking on a bold new "Renovation Wave" plan as part of the European Green Deal. In addition, the Next Generation EU Economic Recovery plans and the Multi Annual Financial Framework provide a not-to-be-missed opportunity to develop and implement effective EU and national policies that will lead to significant GHG emission reductions in the building sector.

2 The UK will leave the EU at the end of 2020, but is committed to reaching climate neutrality by 2050.
3 https://www.cedelft.eu/en/publications/2474/net-zero-buildings-2050

KEY FINDINGS

Current policies will only reduce building emissions by 30% in 2050

The EU is not presently on the path to full decarbonisation of the building sector by 2050. The European reference scenario (European Commission, 2016), which takes into account the energy policies adopted until 2016, shows that in a business-as-usual scenario, GHG emissions from the residential building sector will have decreased by only 30% by 2050, see Figure 1. Even this can only be achieved if policies are implemented correctly. That is not the case at present. For example, Europe is not on track to reach its 20% energy efficiency target in 2020 due to substandard implementation (European Environment Agency, 2019). While this 2050 projection does not include the policies adopted under the Clean Energy Package as they are yet to be implemented at the national level, it is clear that current policies will not lead Europe to net-zero buildings in the desired time frame.

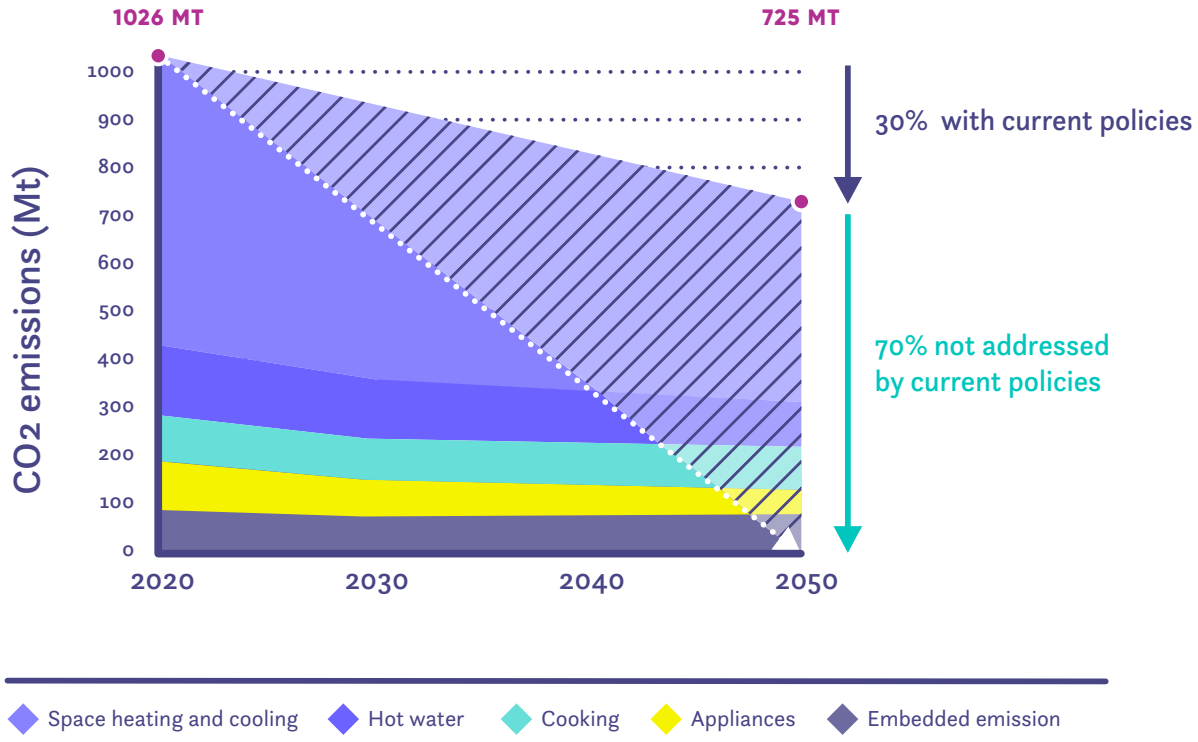


FIGURE 1: *Baseline annual CO2 emissions of residential sector (direct, indirect and embedded emissions). Calculation with EU Calc based on (Röck, 2020) and (European Commission, 2016)*

A drastic reduction in building sector emissions is crucial both from the perspective of reaching full decarbonisation of the whole economy as well as from a cost perspective. A study by Agora Energiewende (ifeu, Fraunhofer IEE and Consentec, 2018) shows that there is no viable alternative to aggressively reducing emissions from the building sector. This is confirmed by an earlier study in this report series, "Towards Fossil Free Energy in 2050" (Element Energy & Cambridge Econometrics, 2019), which highlights in particular that building efficiency measures, in combination with smart technologies, are critical to keeping the energy transition affordable, both from a system cost point of view as well as from a consumer bill one. An incomplete decarbonisation of the building sector by 2050 means that other sectors will have to reduce emissions further.

Decarbonisation of residential buildings requires measures that target all areas: efficiency of the building envelope, heating, appliances, energy carriers and materials

Full decarbonisation of the building sector by 2050 requires highly ambitious measures in every area of the building sector. In order to determine the contribution of different measures, a zero-carbon scenario was developed by Climact using the EUCalc model. This is a model of emissions at the European level, based on user-defined ambition levels for different levers that influence emissions. For this study, the highest ambition levels were chosen for all levers in the building sector[4] and additional assumptions were made for decarbonisation of power and industry to result in a zero-emission scenario for 2050.

Embedded emissions were based on carbon intensities of construction and renovation materials (Röck, 2020). Embedded emissions from appliances, infrastructure and renewable electricity were not included. Reductions in embedded emissions from decarbonised industry (production and end-of-life) are counted as annual emissions reductions to be able to compare them with operational emissions.

4 Except for the demolition rate, which was reduced from 1% to 0.4% per year.

The levers were grouped into five main areas where the building sector emissions can be targeted. These steps towards full decarbonisation are shown in Figure 2. This figure shows the net reduction potential of each main area, compared to the 2050 reference scenario. The five target areas are:

1. **Building envelope:** Improvement of the building envelope of existing and new buildings to reduce energy demand for heating and cooling. A renovation rate of 3% and average energy savings of 55% was assumed. Building envelope measures also lead to an increase of embedded emissions due to the use of materials.
2. **Heating fuel switch:** Decarbonisation of remaining heating demand by switching to or using zero-carbon energy carriers for heating (renewable electricity, district heating, zero-carbon gas and sustainable biomass).[5] This switch encompasses both decarbonisation of the energy carrier (fuel) as well as a different heating system in the building, and often also new or adapted infrastructure (see Box 1).
3. **Appliance efficiency:** Replacement of electrical appliances with more efficient ones.[6]
4. **Renewable electricity:** Decarbonisation of remaining electricity use by switching to 100% renewable power.
5. **Decarbonised materials:** Use of recycled and zero-carbon materials in construction and renovation and switch to 100% decarbonised industry.

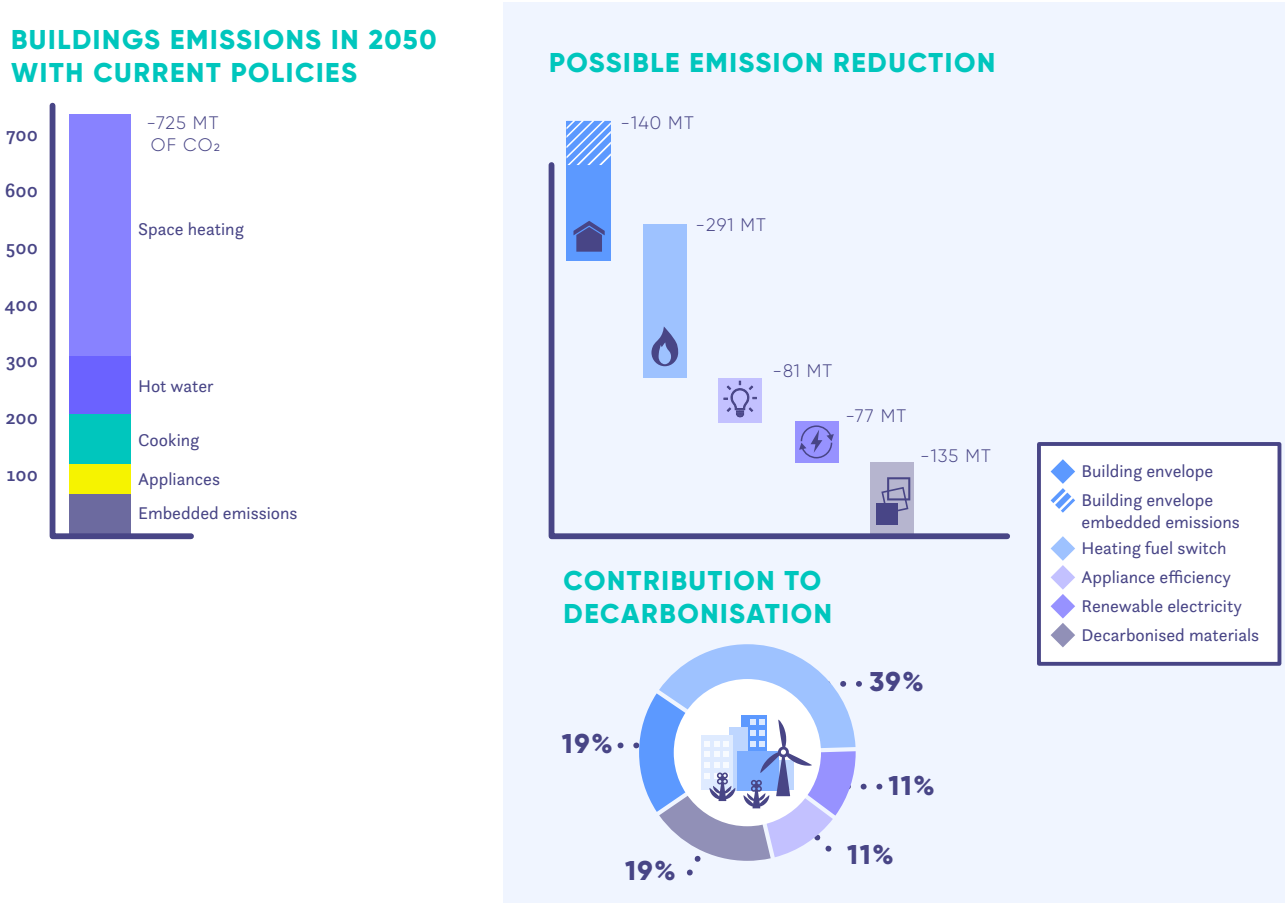


FIGURE 2: *Annual GHG emissions in 2050 reference scenario and net reduction potential of different areas, based on EU Calc*

5 Taking into account that biomass and zero-carbon gas have limited availability, these were assumed to have low shares of total.
6 Appliances are also covered under heating (more efficient heating appliances) and decarbonised materials.

It is clear from these figures that the most important areas for reducing emissions of the building sector are the building envelope, heating fuel switch (see Box 1) and building materials. Therefore this report will focus on these areas.

BOX 1: HEATING FUEL SWITCH

Heating of buildings currently relies heavily on fossil energy carriers (gas, oil and coal). Switching to zero-carbon energy carriers (renewable electricity, district heating, zero-carbon gas, sustainable biomass) is essential. This switch encompasses a change in the building system, infrastructure and energy production. These components of the energy system for heating differ per energy carrier - see Table 1. Consequently, different energy carriers entail different investment decisions: for example, heating with electricity requires the building owner to invest in a heat pump, while district heating requires a collective investment in a district heating network.

	ELECTRICITY	DISTRICT HEATING	ZERO-CARBON GAS	BIOMASS
Building system	Heat pump or electric heating	Heat exchanger	Gas burner	Biomass boiler
Infrastructure	Reinforcement of electricity network	Heat network	Gas network	Biomass pellet supply
Energy carrier	Renewable electricity production	Sustainable heat sources	Zero-carbon gas production	Sustainable biomass production

TABLE 1: *Components of the energy system for heating by different energy carriers*

Zero-carbon gas and biomass are heating options with significant limitations. Zero-carbon gas could be biomethane or (green) hydrogen. Biomethane is produced from biomass; however, the availability of sustainable biomass is highly limited. Estimates for the total potential for sustainable biomethane vary from 7% of the current natural gas demand (ICCT, 2018) to 18% (Navigant, 2019). The availability of biomass and biomethane for buildings is further limited due to demand from other sectors such as industry, power or transport, which may drive up the price. So-called green or zero-carbon hydrogen is hydrogen produced from renewable electricity and has other limitations, as it is not yet available at scale, meaning its future availability and cost remain uncertain. Other sectors like industry and shipping which see fewer decarbonisation alternatives will also need to be given a higher priority for using green hydrogen.

Zero-carbon gas should therefore be considered a 'last resort' solution for buildings with existing gas infrastructure that also cannot be adequately insulated, such as historic buildings, and possibly as part of a hybrid heating solution that will run on decarbonised electricity for the biggest part of the year. Gas network decisions need to consider the scarcity of and competing demands for zero-carbon gases as well as lock-in effects and prioritise all other options, including energy renovations of buildings.

ENERGY CARRIER	ELECTRICITY	DISTRICT HEATING	ZERO-CARBON GAS (HYDROGEN OR BIOMETHANE)	BIOMASS
Heating/cooling appliances	• Heat pump or electric heater • Airconditioning or heat pump	• Heat exchanger	• Gas burner or hybrid heat pump-gas system	• Biomass burners
Infrastructure	• Electricity grid (reinforced)	• District heating network	• Gas network	• Individual transportation of biomass
Production of energy carriers	• Renewable electricity production	• Waste heat, geothermal heat, collective solar	• Sustainable biomass or hydrogen production	• Sustainable biomass production
Built environment characteristics In which types of countries / areas / buildings is this solution cost-efficient?	• New constructions • Well insulated buildings • Low heating demand	• Urban areas • Concentrated heating demand • Suitable for high heating demand	• Existing gas infrastructure • Suitable for high heating demand/ Poorly insulated buildings	• Rural areas • Low density heating demand • Lacking/downgraded gas/ electric infrastructure
Costs and distribution building, infra, heating/cooling appliances, source	• Insulation costs relatively high • Reinforced electricity networks	• Operation costs distributor high • Costs for households low	• Hydrogen currently too expensive for built environment • Gas infrastructure can be reused: low costs	• Appliance costs low • Unknown necessary infrastructure costs
Main barriers and limitations	• High upfront costs of insulation and heat pump • Resistance of owners/residents due to hassle, disruption and aesthetics • Increased electricity demand and high peak demand; impact on grid and renewable production	• Collective investments needed • High upfront costs heat network and renewable heat sources • Resistance of owners/ residents due to monopoly of heat companies, high (perceived) costs, nuisance during construction, lack of control over comfort • Absence of renewable heat source close to network	• Limited availability and competing demands from other sectors Hydrogen: • High cost of producing green hydrogen • Cost for modifying gas network and appliances for hydrogen • Public perception challenges regarding use of hydrogen in homes	• Limited availability of sustainable biomass and competing demands from other sectors • Air pollution and related health effects

TABLE 2: *Components of the energy system for heating for different energy carriers*

When identifying possible policy levers, it is important to realise that a combination of heating solutions, determined by local factors, imposes the lowest overall cost to society. In other words, there is no one single solution, such as electric heat pumps, that will be best for all buildings; rather, a combination of electrification, district heating, gas and biomass will be necessary. Although steering towards just a single solution is feasible, this implies higher costs to society. Policy-makers should therefore be wary of incentivising specific energy carriers and heating appliances at the expense of others. Only if a particular energy carrier plays a prominent role in the country should it be prioritised via policy.

Specific moments for investment (trigger points) should be seized for decarbonisation

Utilising specific moments in the lifetime of investments – trigger points - when the cost and hassle associated with building renovation are less substantial is key to minimising the main barriers for increasing renovation. The building renovation rate and depth need to increase sharply in order to reach the pace of building decarbonisation necessary to reach zero emissions by 2050. Currently, the renovation rate across the EU-28 is 1% per year. The deep renovation rate is much lower, at 0.2-0.3% (European Commission, IPSOS, Navigant, 2019). According to the European Commission, approximately EUR 125 billion in additional yearly investments in the residential sector are needed to reach the EU's current 2030 renewable energy and energy efficiency targets (European Commission, 2019). Given there are 215 million residential buildings in the EU, this amounts to an average of EUR 600/year additional yearly investments per building. In addition, decarbonisation measures in buildings can lead to disruption and hassle for the buildings' occupants. These hurdles can be diminished by choosing trigger points for renovation: key moments in the life of a building when carrying out energy renovations is less disruptive and more economically advantageous than at other moments (BPIE, 2017).

Trigger points offer great potential to increase the renovation rate and depth. Trigger points can be the sale or change of tenancy of a home, non-energy upgrades (e.g. new kitchen, retouching of external façade, adding an extension), a change in household situation (e.g. family expansion, child moving out, renting a room), but also regular (mandated) building inspections. Property transfers are good moments to undertake deep renovations because new owners often want to make changes to their new home anyway, and may not be living in the home yet, creating less hassle. Figure 3 shows the average frequency of some of these trigger points.[7]

FIGURE 3: *Trigger points for investment*

7 Frequency of sales based on 221 million households in EU (Eurostat, 2020), 65% of homes are owner-occupied (Housing Europe, 2017) and approximately 5 million house transactions per year (European Central Bank, 2020). Frequency of change of tenancy based on 25-44% of tenants moved in five years (Eurostat, 2017). Regular inspections are an example of biannual inspections.

The lifetime of investments determines the moment at which new investments can take place at lowest cost. If investments need to be made before the end of the economic lifetime, this incurs extra costs (stranded assets). IRENA (2017) estimates that globally, the costs of stranded assets in the decarbonisation of the building sector will double if policy action is delayed from 2020 to 2030. For individuals, the end of the technical lifetime is the natural moment to replace appliances, such as gas boilers. In addition to the economic opportunity, this replacement moment is one of the few moments for policy to be enforced, such as efficiency standards for new appliances. Figure 3, based on (Agora Energiewende & Agora Verkehrswende, 2019), shows the economic lifetime of a number of investments.

These trigger points are moments to prompt the building owner or other investor to make the decision to renovate and invest in decarbonisation measures. Figure 3-III gives an illustration of the frequency with which different trigger points will likely occur before 2050. This shows the urgency of capitalising on these moments to trigger change before 2050: some types of trigger moments may only occur once between now and 2050. Failing to grasp this opportunity and taking measures at a later time would incur higher costs and more disruption.

Capturing trigger points for renovation is necessary to increase both the rate and depth of renovation. On average, 3% of dwellings need to be renovated each year in order to reach an average energy demand reduction of 54% throughout (the assumption in the modelling with EUCalc). However, Figure 4 shows that this average can be reached in different scenarios. If the energy demand of dwellings can be reduced by an average of 60% every time they change owners (representing 1.7% of the dwellings per year), renovation associated with other key moments would not need to happen at as high a renovation depth.

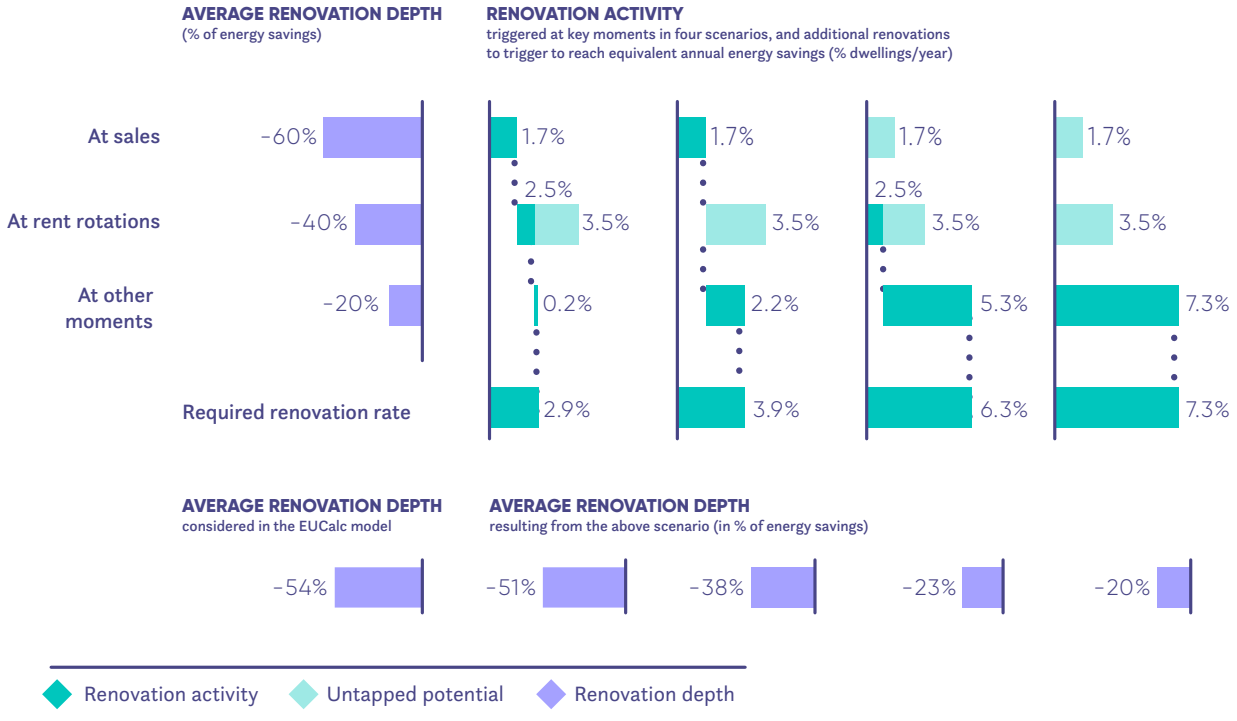


FIGURE 4: *Different renovation rates and depths at key moments reach different average energy savings in four scenarios*

A broad range of regulatory policy instruments are needed in order to reach the full emission reduction potential in the building sector

Regulatory instruments such as norms, standards and minimum requirements are needed to ensure that measures are taken in all areas of the building sector to reach its full decarbonisation potential. Informative and financial policy instruments, on which many countries and the EU rely for the areas with the largest emission reduction potential, are not enough.

These policy instruments, when well-designed, will strengthen each another over time:

- **Informative instruments** such as informational campaigns, technical assistance and training create awareness and enable informed decisions, but do not create an economic or legislative incentive to steer behavior.
- **Financial support** such as subsidies create an economic incentive for decarbonisation measures. However, not all people make use of financial support even if it is available and well-designed.
- **Financing instruments** provide the ability to invest, but only apply where there is already a need or desire to take measures.
- **Pricing** (of e.g. CO_2) creates a level playing field for zero-carbon solutions and a market for innovation. Pricing measures have a wider scope than financial stimulus because they apply to the entire market. However, not all people respond to price signals (price inelasticity) or are able to respond, e.g. due to split incentives between tenant and landlord.
- **Regulatory instruments** ensure that decarbonisation measures are taken, trigger points are utilised, and new customs and habits are formed. Regulatory instruments such as standards and minimum requirements serve as backstop policies to ensure that the full potential is met.

In addition, various policy instruments can be employed to stimulate innovation, discussed later in this report. When these policy instruments are combined in a comprehensive policy package, they enable, incentivise, and ensure full decarbonisation. Together, the policies form a comprehensive pathway towards decarbonisation, see Figure 5.

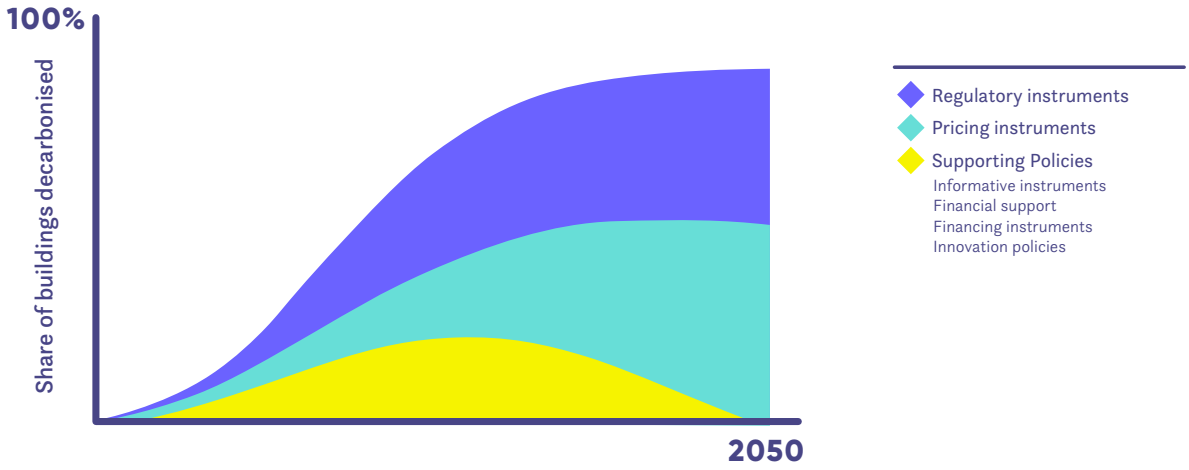


FIGURE 5: *Pathway of policy instruments*

Renovation of the building envelope and a fuel switch for heating will contribute the most to the full decarbonisation of the building sector, but are insufficiently addressed by current EU policy

There is a clear discrepancy between what is needed for decarbonisation and what existing EU policies are targeting. The following current EU Directives set targets for emissions reduction and propose different types of policy instruments to address the areas defined above:

- The **building envelope** is targeted by the Energy Performance of Buildings Directive (EPBD), which introduces minimum energy performance requirements (MEPRs) for new buildings. It also requires minimum energy performance standards for major renovation of existing buildings. In addition, most Member States address the target of 0.8% annual reduction of energy use in the Energy Efficiency Directive (EED) with measures targeting building renovation (building envelope or heating appliances), but the types of policy instruments chosen varies per Member State. Member States can choose between obligation schemes and alternative instruments such as energy or CO2 taxes, financial incentives and voluntary agreements. In many cases, regulatory policy instruments are not chosen (Rosenow, et al., 2015).
- **Switching to zero-carbon heating fuels** is part of the Renewable Energy Directive (REDII) in the form of an indicative target to increase renewable energy for heating by 1.3% annually between 2020 and 2030. There are no pricing or regulatory policies at EU level that help reach this target, but Member States are responsible for implementation.
- **Appliances** are subject to energy efficiency norms set by the Ecodesign Directive and by the Energy Labelling Regulation.
- Decarbonisation of **electricity** is targeted by REDII. The Energy Taxation Directive (ETD) sets a minimum tax for energy, but this does not incentivise decarbonisation of energy carriers, as it is not based on the carbon intensity of the energy carrier. Emissions from electricity production are included in the EU Emissions Trading System (ETS), but the price signals are too low to be an energy efficiency incentive for households.
- **Building materials** are included in the Construction Products Regulation. The Circular Economy Action Plan considers adding circularity requirements, but this still does not include requirements for production emissions.

In short, some target areas are addressed by regulatory policies on the EU level, while others are not covered at all on this level, leaving the implementation to the Member States. As shown in Figure 1, existing policies will only reduce GHG emissions by 30% by 2050. The EU is also not on track to meet its 40% GHG reduction target for 2030, even with additional planned national policies and measures (European Environment Agency, 2019).

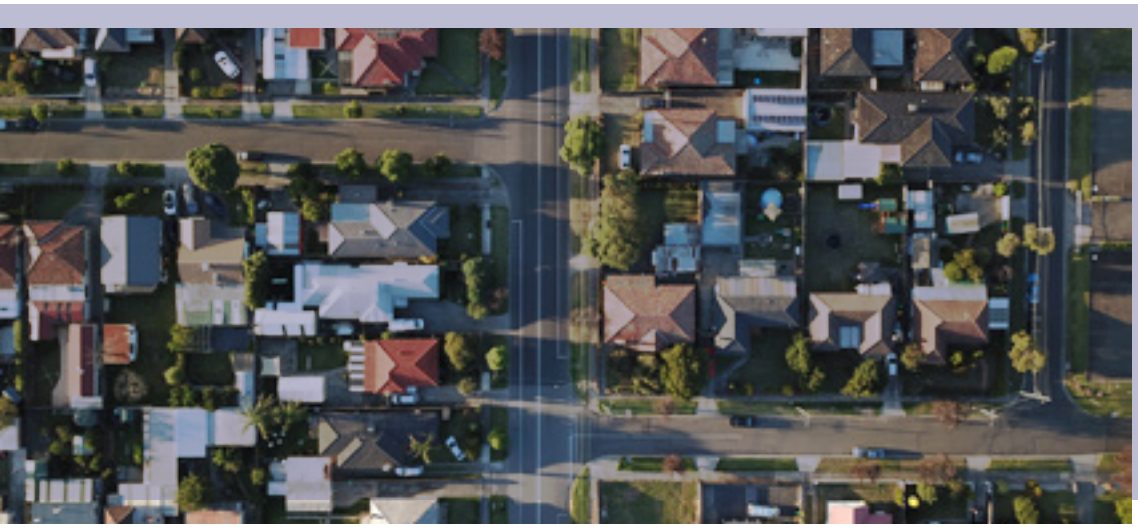
These gaps in the current EU legislation for each area are summarised in Table 3, with the focus on regulatory policy instruments that trigger measures needed to reach the targets.

	BUILDING ENVELOPE	HEATING FUEL SWITCH	APPLIANCES	ELECTRICITY	BUILDING MATERIALS
Existing policy	• Performance requirements for new buildings and major renovations	• Efficiency requirement for heating appliances	• Efficiency requirements for new appliances	• Cap on emissions (ETS)	• Cap on emissions from ETS sectors
Gaps	• Performance requirements for existing buildings	• Cap on emissions for heating fuels Obligation or ban of heating systems Ban on fossil fuel in new constructions			• Lifecycle emissions requirements

TABLE 3: *Gaps in regulatory policy instruments in each target area*

As this table illustrates, binding regulations are lacking in current EU policies in three areas:[8]

- Building envelope of existing buildings
- Heating fuel switch
- Building materials



8 This does not mean that current policy instruments for appliances and electricity are sufficiently ambitious to reach the full potential for these areas, but at least policies are in place and could be strengthened to reach the full emission reduction potential.

Figure 2 shows that these areas have the largest emission reduction potential, while at the same time they have the weakest set of policies on the EU level. It is currently up to the Member States to implement strong policy instruments in these areas to achieve decarbonisation in buildings.

For appliances, regulatory instruments have been in place for a long time, and as a result there has been a large increase in the efficiency in appliances. Therefore, the remaining reduction potential is now much lower than it was before these policies were introduced, although there is still ample reduction potential. Such effective policies are lacking in other areas of the building sector.

In view of the different types of policy instruments discussed in the previous section, it should be noted that the EU is not going beyond supportive policies (information, financial support) in most areas, while stronger policies (pricing, regulatory instruments) are needed now to utilise the trigger points in the building sector and limit costs for society.

In order to reach zero-carbon buildings by 2050, pricing and regulatory policies need to be put in place and strengthened now

By strengthening and expanding the set of policies for the building sector, emissions reduction can be brought on a much steeper trajectory. In current EU policies, the building envelope of existing buildings, heating fuel switch, and building materials are only targeted by financial incentives and informative instruments. This has not led to the increase in demand for building renovation or the level of heating fuel switching that is needed to put Europe on a pathway to zero emissions by 2050. Therefore Europe and its Member States will have to explore and implement policies that are further down the policy pathway in Figure 5, namely, pricing or regulatory policies.

We propose a policy package that consists of pricing and regulatory policies, to be implemented by the EU, with individual Member States. The policy package should at least contain the following components:

- **Minimum energy performance standards** for existing buildings that are applied at key moments in the building's lifetime such as sale and change of tenants, or are set at a certain moment in time and subsequently tightened over time
- **Regulatory policies** for switching in heating fuels and appliances, such as:
  - Cap on CO_2 emissions of energy carriers for energy companies
  - Local or regional heating plans with instrumentation to implement direct electrification of heating and district heating
  - A phasing out of fossil fuel heating systems over time
  - A ban on the use of fossil fuels for heating and cooking in new constructions
- **CO_2-based taxation of energy carriers** for heating, via revision of the ETD, in combination with using the revenues to support low-carbon measures such as deep renovations, especially targeting low-income households
- **Lifecycle emissions requirements** for construction and renovation projects, products and materials
- **Financial support** to supplement these general pricing and regulatory policies, such as re-investment of revenues in building renovation and zero-carbon heating, in order to avoid unintended consequences such as exacerbating energy poverty.

The following sections will elaborate on the different parts of the policy package.

BUILDING ENVELOPE FOR EXISTING BUILDINGS

Binding energy performance requirements are needed to increase demand for building renovation and overcome the barriers. So far, policies for existing buildings are mostly based on informing and financial support mechanisms. They have not led to an increase in the renovation rate. New energy performance policies can be introduced in the short term and can be impactful if set at the right level. At the same time, the EU and Member States' national recovery programmes can help finance the necessary investments to comply with these binding energy performance requirements.

Under existing policy, MEPRs will take effect from 2021, but will apply to new buildings only (EPBD Nearly Zero Energy Buildings regulation). These must be expanded to existing buildings to increase the rate and depth of renovations and create demand for highly efficient buildings. MEPRs need to harness trigger points for renovation: for privately owned buildings, standards can apply to the moment of sale, while for private rental they can apply to the moment at which the building gets new tenants. If a building does not conform to the standard, it will be ineligible for sale or renting until renovated to that standard. For social housing, standards can additionally be linked to renovation plans required by the (national) government according to pre-determined timelines. Box 2 provides some example of the application of MEPRs. The Renovation Wave proposals should be used to introduce this instrument, and the national recovery plans can provide the necessary short-term stimulus packages to implement this at national level.

In many cases, buildings will not change ownership or tenancy frequently enough before 2050. Therefore, energy efficiency requirements may also have to include buildings during the same ownership or rental, while striving to keep disruption to a minimum. As a matter of principle, the requirements should be applied in a manner that is socially just. For example, tenancies should be protected through rent regulations to maintain affordability after renovation.

BOX 2: MEPRS IN THE NETHERLANDS AND SPAIN

The Netherlands has energy performance requirements for a subset of the existing building stock. The social housing sector committed to reaching an average energy label B by 2020 in a voluntary agreement. The share of social housing is significant, comprising 30% of the residential building stock in the Netherlands (Housing Europe, 2017). Furthermore, an energy performance requirement for existing office buildings was implemented in 2012. By 2023, all office buildings must have energy label C or they will not be allowed to be used as offices. In theory, this regulation is easier to implement for office buildings than for residential buildings, because office buildings often have five-year lease contracts (ING, 2016). In 2016, 52% of office floor space was estimated to have insufficient energy performance (EIB & ECN, 2016). As a result of this legislation, banks are actively looking to 'green' their portfolio by only offering new loans for buildings that comply to the standard or that have a plan to improve their performance (ING, 2016).

Examples of MEPRs for new buildings are widely available. The Netherlands implemented an energy performance coefficient requirement for new buildings in 1995 that has been gradually increased to Nearly Zero Energy in 2020. The energy performance calculation is part of the building permit application. The coefficient is based on the estimated total primary energy consumption of a building based on a series of indicators, e.g., heating, ventilation and lighting, adjusted to the useful floor area and the renewable energy produced by the building. The requirement can therefore be met in different ways, giving the developer flexibility in how to comply with the requirement in different circumstances (van Eck, 2016). This design also allows for innovation: new techniques that were not known when the policy was developed, can nevertheless be employed to comply with the standard. A drawback is that the calculation is fairly complex, requiring a comprehensive study on the part of the developers in order to comply with the law.

In Spain, the Technical Building Code for new buildings includes requirements for solar water heating, in addition to requirements for the energy demand, heating equipment and renewable energy use of buildings (Ministerio de Fomento, 2013). The building code also distinguishes between five climatic regions in Spain: a good example of the need for regional specificity of norms and standards.

In addition to regulatory policies, which can function as backstop policies to ensure the full potential is reached, renovation can be incentivised through information, financing and price signals. Pricing instruments can consist of property taxes or sales taxes based on the energy performance of the building, providing a financial incentive to improve the energy performance. However, these policies are not sufficient on their own: rather they support regulatory policies, to increase the speed of uptake and, in the case of financial support, reduce effects such as energy poverty.

SWITCHING TO ZERO-CARBON HEATING FUELS AND SYSTEMS

75% of heating of the built environment is based on fossil fuels (gas, oil and coal) (Eurostat, 2018). Switching to decarbonised energy carriers for heating is therefore essential to reduce GHG emissions in the building sector. Energy carriers for heating largely fall outside the scope of current legislation, despite the (indicative) RED target of a 1.3% annual increase in renewable energy in heating. The only exception here is electricity produced for heating which falls under the ETS.

The fuel switch for heating necessitates a change in all parts of the energy system for heating: the building heating system (including heating appliance), infrastructure, and energy production. The necessary systems, however, vary based on the alternative heating solution, as shown in Figure 3. To stimulate a switch to zero-carbon heating fuels, a combination of regulatory instruments and CO2 pricing will be most effective.

Regulatory policy instruments are needed to both ensure that the trigger points are being leveraged and to serve as a backstop. The RED sets an indicative target of 1.3% annual increase in renewable heating between 2020 and 2030. The first way in which Member States can implement this requirement is to direct regulatory instruments towards the energy companies, by imposing a cap (permit) on the carbon emissions of the energy (electricity, gas, district heat, coal, oil) that an energy company sells. This cap is reduced to zero over time. The emission permits may be traded between energy companies. The additional costs needed for decarbonisation measures to meet this cap are passed on to the energy consumers, where it has the same effects as carbon pricing. To ensure the policy is effective and does not lead to unintended effects, stricter definitions of lifecycle GHG emissions from hydrogen, biomethane and biomass are needed. This system resembles the EU ETS, but requires a separate emissions cap, as building sector emissions are part of the Effort Sharing Regulation and inclusion in the EU ETS would have unwanted side effects (Cambridge Econometrics, 2020).

A different way to impose mandatory norms or obligations for a switch in heating fuel is by targeting consumers. However, this is difficult, because the cost-efficiency of different heating solutions is situation-specific, and some solutions like zero-carbon gases come with significant limitations in terms of how much can be sustainably sourced and what needs other sectors have for them. In addition, the lowest cost options for society are often not reflected in the business cases for the supplier or cost savings for the consumer.

Local or regional heating plans can overcome this challenge by identifying optimal heating solutions and steering policies towards this outcome. To make these plans, local governments need to analyse the building stock to determine where certain solutions are available and which are most cost-efficient from a societal perspective. These heating plans should be co-developed with residents to ensure broad support.

The EED requires each EU Member State to carry out an assessment of the national potential of highly efficient district heating and cooling. This potential needs to be elaborated into local, specific areas, and can be combined with the local or regional heating plans mentioned in the section above. In order to follow up on these plans, regional or local authorities need to be given the mandate to assign and implement district heating in those areas if this sustainable heating solution leads to the lowest cost for society (see Box 3). This requirement in the EED needs to be turned into a requirement for Member States to support local and regional government in developing local and regional heating plans.

BOX 3: POLICIES FOR THE 'HEATING TRANSITION' IN THE NETHERLANDS

The Netherlands has committed itself to phase out natural gas for residential heating by 2050, and it's the first country to commit to such an ambition (BloombergNEF, 2020). This sets a clear direction for policy-making. Current policy instruments include a switch in taxation from electricity to gas, local heating plans, and neighbourhood subsidy schemes.

Municipal governments are required to develop a local heating plan indicating which alternative heating solution is the most promising on a neighbourhood level. This solution should be based on lowest total costs for society. The national government assists with techno-economic modelling and provides subsidies for municipalities to implement a chosen heating strategy in selected neighbourhoods. The local heating plans are part of a larger set of policy instruments still under development that will further assist local governments in realising these plans, extending further than these subsidy schemes.

The local heating plans are an important step in defining a strategy for the decarbonisation of heating and for communication with and dedicated support to residents. However, the current subsidy schemes have not yet resulted in significant implementation of the plans (Algemene Rekenkamer, 2020). Additional policy instruments are needed to ensure successful implementation of the heating plans.

Under the condition that alternative heating energy carriers and appliances are available and affordable, legislation can in the longer term ban fossil fuel-based heating systems such as gas or coal boilers, or even gas networks in specific areas. A step to move towards a phasing out of fossil-based heating systems is the implementation of increasingly strict energy efficiency requirements for new heating appliances.

Finally, heating and cooking based on fossil fuels needs to be banned in new constructions. By the end of 2020, new constructions will have to be nearly zero energy, resulting in very low energy demand. This remaining demand should be covered by sustainable energy.

In addition to regulatory instruments, policies that impact pricing of the energy carriers create a market incentive to switch to decarbonised carriers as well as for efficiency measures. In contrast to subsidies or efficiency standards, this incentive applies to all energy users. Pricing imposes a price or tax on carbon within the energy carrier (electricity, gas, oil, coal). While electricity currently falls under the ETS, gas and district heating do not. The current energy taxation system (ETD) is based on energy content, while some countries have experience with a carbon-based tax (CE Delft, 2019). Switching to a CO_2-based taxation on the EU or national level would stimulate the production and use of renewable energy carriers for heating (CE Delft, 2019).

A CO_2 price works best if it is imposed on all energy carriers (electricity, gas, oil), while removing additional tariffs on electricity, so that the different energy carriers are put on a level playing field. The tax can be levied close to the producer or at the end user, but in both cases consumers will ultimately pay the tax via their energy bills. The pricing of CO_2 will incentivise both the reduction of energy demand and a switch to renewable energy carriers. In the case of gas for example, a CO_2 tax would increase the price of natural gas, but not of renewable options, creating a more level playing field for alternatives such as renewable electricity, district heat, or biomethane. Calculations for the Netherlands show that a CO_2 price of EUR 43/ton will reduce the use of natural gas by almost half in a cost-effective scenario (CE Delft, 2019). However, due to the low price elasticity for heating fuels in general, pricing must be accompanied by supporting and regulatory policies.

A drawback of CO_2-pricing is the increase of energy poverty if no additional measures are taken. Energy poverty can be alleviated or prevented through deliberate policy measures, supporting the general pricing and regulatory policies:

- Re-investment of revenues and additional financial support of building efficiency measures targeted towards lower income groups, such as modernisation schemes for multi-family blocks and providing free insulation measures (see Box 4)
- Energy allowance, e.g. through energy tax exemption or deduction
- Progressive energy taxation, where an increase in consumption corresponds to an increase in unit price.

BOX 4: ENERGY POVERTY MEASURES UNDER THE POLISH CLEAN AIR PROGRAMME

Under the Polish Clean Air Programme, special rulings are in place for energy-poor households. Municipalities can receive grants from the Clean Air Programme to support energy-poor living in single-family homes by investing in insulating their homes and replacing their heating equipment. One of the solutions for municipalities is connecting single-family buildings where the energy-poor reside to district heating.[9]

9 See Stop Smog Programme webpage: https://czystepowietrze.gov.pl/stop-smog/

REDUCING EMBEDDED EMISSIONS OF BUILDING MATERIALS

Existing supply-side policies have not been effective in reducing embedded emissions of construction and renovation materials, which contribute a rising percentage of total residential building sector emissions. Embedded emissions are the carbon emissions associated with materials and construction processes throughout the whole lifecycle of a building or infrastructure. They currently contribute to 8% of total emissions from the residential building sector, and this share will increase over time (see Figure 1). Current industry policies regulating the production of construction materials such as the EU ETS have not reduced embedded emissions and the emissions reduction is not on track to reach its objectives (European Environment Agency, 2019b).

Decarbonisation of materials and industry also needs to be driven by policy targeting the demand side, by introducing requirements for the buildings and construction sector that create a market for low-carbon materials and products that are low-carbon and may have higher prices than conventional alternatives. These requirements should target operational and embodied emissions ("whole life carbon") in an integrated manner to avoid having a situation where requirements on embodied emissions disincentivise efforts to tackle operational emissions (WGBC, 2019). Such a requirement targets the objective of decarbonisation, while leaving room for different solutions to reach this objective to be used, in contrast to setting a requirement for the use of a certain specific solution (such as targets for a percentage of recycled materials or wood building). In order to facilitate this building-level approach, the Level(s) framework was developed. Level(s) is a voluntary reporting framework on building sustainability. The framework is currently being tested (European Commission, 2020).

A first step towards including whole life carbon in requirements is to explore how this can be used in procurement, such as described in the EU Circular Economy Action Plan. The EPBD provides an opportunity to set specific requirements for the climate performance of buildings. Its scope can be extended to set criteria for both operational and embodied emissions in the transition to net-zero carbon buildings. This can ensure that lifecycle carbon emissions are considered in the design of new buildings and major renovations.

TIMELINE

The full decarbonisation of the building sector requires comprehensive policy packages that consist of a mix of policy instruments, that together create demand for and an uptake of building renovation, zero-carbon heating and decarbonised materials. Since the areas within the building sector all have long investment lifetimes and other trigger moments occur infrequently (see Figure 3), pricing and regulatory policies are needed urgently so that these investment cycles can be optimised.

There is a pathway towards more binding policies that can receive broad support. Pricing and regulatory instruments need to start at a low level and be announced well in advance so that consumers can plan for this change, supply chains can develop, and companies and investors know where to focus. In parallel, financial support is needed to facilitate the transition and to ensure that it is just for all, including energy-poor households. After implementation, the price levels, requirements and standards need to increase or be strengthened by setting intermediate objectives in line with the EU targets, to reach 100% decarbonisation by 2050, and this timeline should be announced in advance.

STIMULATING INNOVATION TO ACHIEVE DECARBONISATION

To transition to a net-zero emission economy by or before 2050, all available technologies will need to be scaled up and deployed at an exceptional pace. This transition also requires rapidly increasing the readiness and deployment of a next generation of low-carbon technologies, innovative and enabling business models and customer engagement. Through innovation, renovation and decarbonised heating can be transformed and accelerated much like what has happened for solar PV and LEDs.

Innovation in the building sector goes beyond new technologies like heat pumps, sensors and low-carbon building materials, and also includes product innovation (e.g. prefabricated building components), business model innovation (e.g. the Dutch Energiesprong project), and societal innovation (e.g. acceptance of new technologies or aesthetics).

In addition, innovation is essential to reduce the cost of decarbonisation measures and to overcome other barriers for decarbonisation, such as the hassle of renovations and lack of information about the performance of solutions. In addition, innovation will contribute to other objectives besides decarbonisation, such as climate resilience and a circular economy.

In order to stimulate this innovation in the building sector, policies need to go beyond financing for research and innovation (R&I). Regulatory policies are needed to create a pull from the market. These policies will not only help decarbonisation with existing technology and business models, but also create the need or market for new solutions.

In order to scale up innovation, both an improvement of the conditions for innovation on the supply side as well as a market demand for innovative decarbonisation solutions are needed. Policies so far have focused on financing schemes for research and innovation, but have not changed the market to create this demand. Financing schemes for innovative products are a way to create demand, but are not sufficient by themselves due to limited response from the market.

Therefore, regulation is needed to trigger a "pull" from the market and create a level playing field that makes innovative solutions competitive. One such policy instrument is MEPRs or Building Performance Standards for existing buildings. These set a minimum standard every time a home is renovated, sold or rented out, or at a certain moment in time (such as the Dutch requirement on commercial buildings). Standards can target the building envelope, equipment, or a combination. These standards need to consistently improve towards the necessary level for 2050. Requirements are also needed in the area of embedded emissions to create demand for decarbonised materials.

On the supply side, innovation can be stimulated by traditional R&I funding, but can also benefit from measures that target specific barriers in the building sector:

- Funding for innovation in the construction industry: The construction and renovation sector is dominated by small and medium enterprises (SMEs), which often have limited time and resources for innovation. Therefore, these businesses need financial support to innovate. Subsidies or tax incentives for businesses that form collaborative offers additionally help integrate the supply chain (see Box 5).
- Creation of innovation ecosystems: Innovation "hubs" can connect different actors in the innovation value chain, including universities, technology suppliers and construction companies.

BOX 5: STIMULATING INNOVATION IN POLAND THROUGH SME GRANTS

Poland has developed a grant scheme to stimulate coal boiler manufacturers to switch to heat pump production.

The Intelligent Development Operational Programme is a large innovation subsidy programme that stimulates research and development. It is co-financed by the European Regional Development Fund. It includes a subsidy programme of 200 million PLN (48 million euro) for research institutions, consortia and SMEs to develop low-emission heating technologies (Narodowe Centrum Badań i Rozwoju, 2019).

Regulatory policies can be met with resistance if implemented abruptly, but backlash can be prevented in numerous ways. Policies and frameworks can be co-designed with citizens and market parties using citizen consultation practices. In addition, standards and norms can be introduced at more acceptable lower levels and strengthened over time. New buildings will also help drive change in the construction sector. By demonstrating that buildings can be smarter, more efficient, more comfortable, and healthier, new buildings can prompt household demand for better existing buildings. At the same time, contractors and developers will develop the expertise to apply similar technologies in renovations.

Beyond policies to increase technology, business model and societal innovation, innovation in the policy-making process itself is needed to create more effective policies and citizen support. Citizen consultation and co-design of policies are an example of this. Also, policies can be developed that are integrative in their approach in order to target multiple barriers (see Box 6).

BOX 6: INTEGRATIVE APPROACH IN THE PAREER-CRECE PROGRAMME IN SPAIN

The PAREER-CRECE programme is a fund which grants financial aid and repayable loans to projects that improve the energy performance of buildings. Apart from financial aid, the PAREER-CRECE programme also offers technical expertise, help with procedures and help with identifying partners. Therefore, a single operator can assist during the entire process of renovation which makes it easier for homeowners to invest (Ministerio de Fomento, 2017).

If demand is created for innovation in the building sector, a large market can be developed inside and outside the EU, with multiple co-benefits such as the creation of (qualified) jobs, circularity, and shorter supply chains. Building innovation could have a transformational effect as it has had in other sectors. To achieve that, innovation needs to be stimulated, not only by financial support of R&I projects and demonstrators, but by setting the right framework for deployment through regulatory policies.

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