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Stepping up Europe's 2030 climate ambition
Investing in a climate-neutral future for the benefit of our people

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PART 1/2

COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT

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**COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN
PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL
COMMITTEE AND THE COMMITTEE OF THE REGIONS**

Stepping up Europe's 2030 climate ambition

Investing in a climate-neutral future for the benefit of our people

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1 INTRODUCTION: POLITICAL AND LEGAL CONTEXT

1.1 Context of the initiative

Global warming is happening and is already affecting citizens, confirming the urgent case for action that science has presented for some time. Temperatures continue to break records and climate-related extreme events are more frequent and more intense¹. At the same time, low emission technologies and business models are becoming more competitive and Europe's citizens have continued to call for stronger climate action, in line with the Paris Agreement goal of keeping global temperature increase well below 2°C and pursuing efforts to limit the increase to 1.5°C.

The President of the European Commission has made the European Green Deal a priority for her mandate from the start. The European Green Deal resets the Commission's commitment to tackling climate and environmental-related challenges and introduces the green oath to "do no harm". It is essential as a roadmap and a growth strategy towards a prosperous and healthy future. Its necessity and value has only grown in light of the very severe effects of the COVID-19 pandemic on our health and economic well-being. Unprecedented near term investments will be needed to overcome the negative impact of the COVID-19 crisis on jobs, incomes and businesses. The Commission realises that the political choices we make today will define the future for the next generations.

That is why the European Commission wants to build a green, digital, inclusive, and resilient economy that is fit for the 21st century. The European Green Deal thus aims to transform the EU into a fairer and more prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use. The European Green Deal Communication² includes a dedicated roadmap with key policies and measures to further this transformation.

Globally greenhouse gas emissions are not on track to achieve the temperature goals of the Paris Agreement to keep global warming well below 2°C, and pursuing efforts to limit the increase to 1.5°C. EU action alone cannot deliver the required global emission reductions but the EU has accepted the challenge of demonstrating to our partners that increased climate ambition, economic prosperity and sustainable growth can go hand in hand.

2020 and the next major UN climate conference, COP 26, in Glasgow in 2021, will be important in this context. Parties are expected to update their Nationally Determined Contributions (NDCs) this year, following submission of their first NDCs back in 2015, as well as to submit long-term strategies outlining their visions for reducing emissions towards 2050³. By increasing its domestic 2030 greenhouse gas target, the EU would be in a position to update and enhance its NDC, in 2020 and before COP26, in line with the requests from the [European Council](#) and

¹ Impacts of climate change in the EU and globally and the need to adapt to it are not the focus of this assessment. Nevertheless Annex **Error! Reference source not found.** includes a detailed discussion of issues at stake in this context.

² COM(2020)640

³ NDCs are housed in the interim NDC registry. <https://www4.unfccc.int/sites/NDCStaging/Pages/Home.aspx>
Long-term strategies are housed on the UNFCCC website. <https://unfccc.int/process/the-paris-agreement/long-term-strategies>

Parliament⁴. The EU has already submitted to the UNFCCC its Long-Term Strategy⁵, which confirms its objective of achieving a climate neutral EU by 2050.

1.2 Current policies and progress achieved

2020 perspective

In 2007, the European Union adopted the first dedicated energy and climate policy package to address at the same time emissions reduction and energy sector reform. The package set national energy and climate targets for the year 2020 improved and extended the EU Emissions Trading System (EU ETS)⁶; adopted legislative schemes for renewable energy (the Renewable Energy Directive – RED I) and energy efficiency (the Energy Efficiency Directive - EED) and put in place the 3rd package of energy market liberalisation. The implementation of the legislation that emerged clearly facilitated a faster transition to a decarbonised energy sector.

The EU is on track to overachieve its target under the UN Framework Convention on Climate Change (UNFCCC) of reducing greenhouse gas (GHG) emissions by 20% by 2020. In 2018 EU GHG emissions, excluding the UK and including emissions of all outgoing aviation were 20.7% below 1990 levels⁷. Including net absorptions and emissions of the EU's Land-Use, Land-Use Change and Forestry sector, net emissions have reduced by 22% compared to 1990.

The EU has also set a 20% energy efficiency target for 2020. Final energy consumption in the EU28⁸ fell by 5.8%, from 1194 Mtoe in 2005 to 1124 Mtoe in 2018. This is 3.5% above the 2020 final energy consumption target of 1086 Mtoe. Primary energy consumption in the EU28 decreased from 1721 Mtoe in 2005 to 1552 Mtoe in 2018 – a 9.8% drop. This is 4.65% above the 2020 target of 1483 Mtoe.

The third target for 2020 aims at a 20% share of renewable energy in gross final energy consumption. Renewable energy has been increasing continuously in the EU. Helped by Member States support policies, the share of renewable energy in gross final energy consumption grew from 9.6% to 18.9% in the period between 2004 and 2018. This result put the Union on track to reach its target for 2020⁹. Over this period, direct and indirect employments in renewable energy in the EU28 more than doubled, increasing from 660 000 to 1.51 million jobs¹⁰.

The European power system has coped with the rise of variable renewables. Policy and regulatory measures have been instrumental in developing interconnected and integrated trans-European electricity markets. Forty projects – of which 30 related to power networks – have been implemented under the TEN-E policy framework aimed at improving cross-border exchange.

2030 perspective

The EU's existing climate target for 2030, to reduce emissions domestically by at least 40%

⁴ European Council Conclusions, 14 December 2019 and European Parliament resolution of 15 January 2020 on the European Green Deal (2019/2956(RSP))

⁵ <https://unfccc.int/documents/210328>

⁶ Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a system for greenhouse gas emission allowance trading within the Union and amending Council Directive 96/61/EC

⁷ EEA Greenhouse Data viewer, EU27 emissions (Convention basis), <https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer>

⁸ Energy efficiency target for 2020 are set for the EU28 using FEC2020-2030 and PEC2020-2030 indicators.

⁹ With some Member States overachieving and some underachieving their national targets.

¹⁰ <https://www.eurobserv-er.org/>. Data for the EU28. Excluding the UK 1,38 million jobs in 2018 in the renewables sector.

compared to 1990, was set in 2014 in the context of an EU objective to achieve GHG emission reductions of 80-95% in 2050 compared to 1990¹¹. The GHG target was incorporated in the EU Nationally Determined Contribution (NDC) to the Paris Agreement. It was implemented in three main pieces of legislation:

First the EU Emission Trading System (ETS) directive¹², which regulates GHG emissions from large point sources (mainly power sector and industry) and aviation was revised. The annual ETS cap reduction was increased and the Market Stability Reserve (MSR) was strengthened to address the surplus of EU allowances that has built up historically. Second the Effort Sharing Regulation (ESR)¹³ was adopted setting binding emission trajectories and reduction objectives per Member State up to 2030, taking into account their different capabilities to reduce GHG emissions. Combined these two pieces of legislation would ensure emissions in the EU, excluding LULUCF and including aviation, decrease by 40% compared to 1990. Third the Land Use, Land Use Change and Forestry (LULUCF) Regulation¹⁴ was adopted. This ensures land use, land use change and forestry is included in the EU regulatory framework and requires that the net sink from land use does not deteriorate compared to how it would have evolved continuing existing land use management practices. Any credits generated beyond the accounted sink can also contribute to achieve at least 40% GHG reductions and the EU NDC.

The EU also adopted a comprehensive update of its energy policy framework to facilitate the energy transition and to deliver on the EU's commitments under the Paris Agreement. The Clean Energy for All Europeans package consists of eight legislative acts setting the European energy targets for 2030 and paving the way for their achievement. The new legal framework set an EU binding target of at least 32% for renewable energy sources in the EU's energy mix and of at least 32.5% energy efficiency by 2030. Key roles are played by energy efficiency legislation, notably the amended Energy Efficiency Directive¹⁵ as well as by the legislation related to renewables with the Renewable Energy Directive (RED II) recast¹⁶ at its centre. The package also includes legislation to adapt the electricity market design to increasing shares of decentralised and variable generation assets.

If fully implemented with all targets fully met, this energy and climate legislation is expected to reduce greenhouse gas emissions by more than 40% in 2030 compared to 1990, as shown in section 5.1.

The Regulation of the Governance of the Energy Union and Climate Action has established an integrated energy and climate planning, monitoring and reporting framework¹⁷. It has created a

¹¹ European Council (23 and 24 October 2014), Conclusions on 2030 Climate and Energy Policy Framework

¹² Directive (EU) 2018/410 amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments, and Decision (EU) 2015/1814

¹³ Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013

¹⁴ Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU

¹⁵ Directive (EU) 2018/844

¹⁶ Directive (EU) 2018/2001

¹⁷ Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council

unique system of energy and climate governance ensuring that the Union and its Member States can plan together and fulfil collectively the 2030 targets. Member States have, for the first time, prepared integrated National Energy and Climate Plans (NECPs) and a similar process of preparing National Forestry Accounting Plans was also followed for the establishment of key benchmarks for forestry accounting, under the LULUCF Regulation¹⁸.

All Member States have submitted their final NECPs. Based on the aggregation of the projections reflecting national measures currently planned, the Commission has made an analysis of total GHG emission reductions excluding the net LULUCF sink¹⁹: they are estimated to decrease by 41% by 2030 compared to 1990²⁰, while in the non-ETS sectors excluding the net LULUCF sink the planned reductions amount to 32% compared to 2005²¹. The analysis also indicates that the share of renewable energy would reach between 33% and 33.7% and the levels of primary and final energy consumption would show a gap of 2.8 p.p. and 3.1 p.p. respectively compared to the target of at least 32.5% by 2030. Overall the final NECPs confirm that the EU legislation and Member States planned policies to achieve the current 2030 energy targets can lead to overachievement of the current 2030 climate target of at least 40% domestic GHG reductions but that currently planned policies still fall short of achieving the full implementation 2030 Energy Efficiency targets. In the 2020 State of the Energy Union report, the Commission will assess the individual final plans including in the context of current EU-level non-ETS, energy efficiency and renewable energy targets.

2050 climate neutrality

Following the Union's commitments to implement the ambitious Paris Agreement, which includes the need to develop a long term low greenhouse gas emission development strategy, the Commission set out in November 2018 its long-term strategic vision for a prosperous, modern, competitive and climate neutral EU in the Communication “A Clean Planet For All”²². The strategy shows how Europe can lead the way to climate neutrality while ensuring just transition and prosperity. By 2050 the EU would achieve net zero greenhouse gas emissions, with any remaining GHG emissions compensated by an equivalent amount of removals.

This allowed for a broad societal debate on the opportunities and challenges related to this transition, including in depth discussions in EU Member States, the European Parliament and different Council formations. In 2019, first the European Parliament²³ and subsequently the European Council²⁴ endorsed the long-term EU objective of climate neutrality by 2050. The

¹⁸ SWD(2019) 213 final, COMMISSION STAFF WORKING DOCUMENT, ASSESSMENT OF THE NATIONAL FORESTRY ACCOUNTING PLANS <https://europa.eu/!yp46uj>

¹⁹ Including intra and extra EU aviation, excluding international maritime navigation.

²⁰ Based on final submitted NECPs with an aggregation method similar to the methodology applied in SWD(2019) 212 final, i.e. using “with additional measures projections” as in the NECP’s with the exception that for those Member States that have set a more ambitious national target in legislation, this gets preference on any “with additional measures projections” projection.

²¹ Based on final submitted NECPs aggregating the 2030 greenhouse gas projections “with additional measures” for effort sharing sectors that were included in the NECP. For the few Member States for which such projections are not available, either ESD targets or supplementary “with additional measures projections” submitted under Regulation (EU) No. 525/2013 have been used. The 2005 base year values as used under the Effort Sharing Decision and published e.g. in SWD(2018) 453 have been used unless Member State updates thereof are available from the NECPs.

²² COM/2018/773

²³ European Parliament resolution of 14 March 2019 on climate change – a European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy in accordance with the Paris Agreement

²⁴ European Council Conclusions of 12 December 2019 (EUCO 29/19)

European Union submitted in March 2020 its long-term strategy, including this objective, to the United Nations Framework Convention on Climate Change (UNFCCC) ⁵.

The objective of climate neutrality by 2050 is at the heart of the European Green Deal presented by the Commission in December 2019. In the first European Climate Law²⁵, the Commission proposed to translate the political commitment into a legal obligation for the Union that provides for increased investment certainty. The Climate Law proposal also aims to integrate an updated Union's 2030 climate target, as well as a trajectory which can allow the Commission to assess periodically progress towards the 2050 objective. Defining this starting point of the trajectory in the proposed Climate Law is also an objective of this initiative, which looks into increasing the 2030 GHG emissions reduction target to 50-55% compared to 1990 levels in a responsible way.

For a more detailed overview of the current state of achievement of the 2020 climate and energy framework and its related targets, see annex 9.10.1.1. For more detail on the legislation contained in the 2030 climate and energy framework see annex 9.10.1.2.

²⁵ COM/2020/80

2 PROBLEM DEFINITION

The problem is that the current level of policy ambition for 2030 is not sufficient to allow for a gradual transition to a climate neutral EU economy by 2050, with both the level of the 2030 climate target and the policy framework being inadequate.

This Impact Assessment analyses policy options related to this problem and aims to inform a decision not only on the 2030 GHG reduction target but also, if deemed necessary, on the appropriate level of EU ambition for renewable energy and energy efficiency in 2030.

The Impact Assessment will also allow for some political decisions as in the priority areas for the legislative initiatives to be adopted by June 2021 - in order to achieve the overall ambition in a coherent manner. However, given the magnitude of the policy changes needed, this Impact Assessment does not discuss precise sectoral measures, which will be addressed in a series of detailed Impact Assessments accompanying proposals of legislative acts scheduled for June 2021.

2.1 The 2030 climate target is insufficient

In 2019, the European Parliament²⁶ and the European Council²⁷ endorsed the EU objective of climate neutrality by 2050. However, the current 2030 GHG emissions reduction target of at least 40% (compared to 1990 levels) was agreed before the EU climate neutrality objective was adopted and is based on a less ambitious pathway, i.e. one that would lead to achieve at least 80% GHG emission reductions domestically by 2050. The current target therefore risks incentivising decisions by policymakers and investors that could lock in emissions trends inconsistent with EU climate neutrality by 2050.

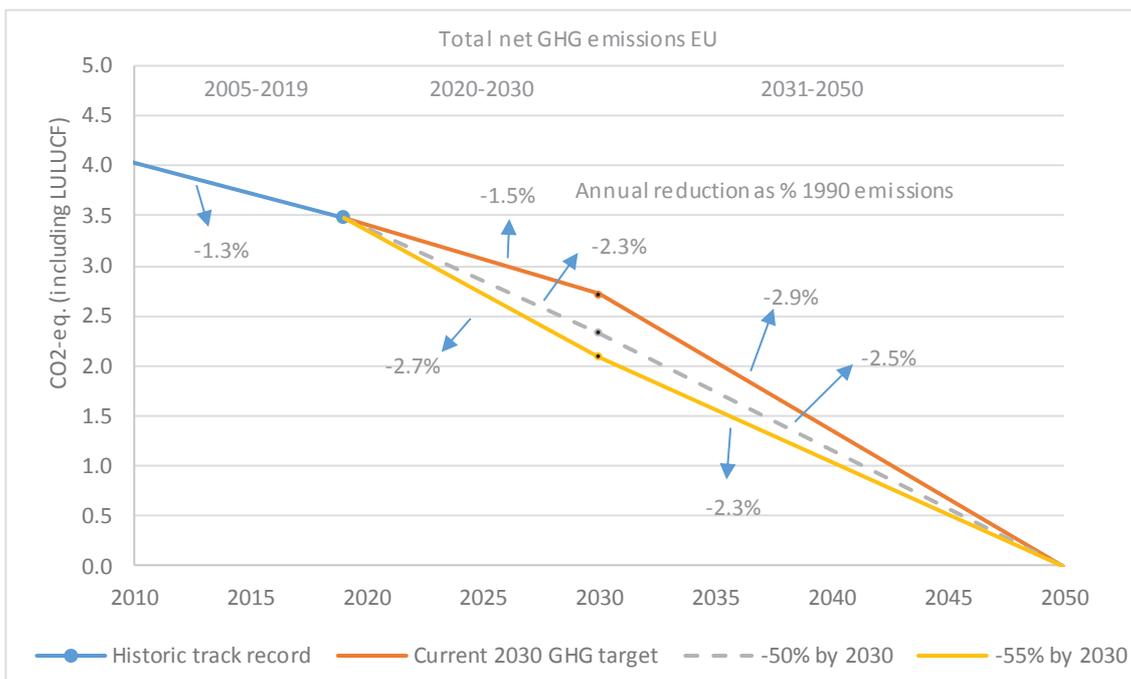
A 40% reduction of GHG emissions target compared to 1990 is insufficient to put the EU economy on a balanced path towards climate neutrality by 2050 and requires larger reductions after 2030 than before, as shown in Figure 1 which represents in a stylised manner the current 2030 GHG target (using the latest 2018 GHG inventory data and including net LULUCF emissions and absorptions)²⁸. What is clear is under existing climate legislation up to 2030, the current legislated pathway would require a significant part of the transition to be concentrated in the period after 2030.

²⁶ European Parliament resolution of 14 March 2019 on climate change – a European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy in accordance with the Paris Agreement

²⁷ European Council Conclusions of 12 December 2019 (EUCO 29/19)

²⁸ Note that annual reductions in Figure 1 are expressed in a linear trend and as % of 1990 net emissions. This is not the same as an annual reduction rate which is sometimes also used as a metric to express climate ambition. This later metric typically gives higher percentages. For instance to reduce emissions between 2018 and 2030 by as much as the linear trend of 2.7% of 1990 emissions requires an annual reduction rate between 2018 and 2030 of 4.5%. To reduce emissions between 2030 and 2035 by as much as the linear trend of 2.3% of 1990 emissions requires an annual reduction rate between 2030 and 2035 of 5.6%.

Figure 1: Stylised representation of future net GHG emission pathways compared to historic reduction rate since 1990



Source: Based on data from the Greenhouse Gas Data viewer of the European Environmental Agency, own calculations

The full achievement of the currently legislated 2030 energy targets of at least 32% renewable energy in the EU energy consumption and of an improvement in energy efficiency of at least 32.5% at EU level, together with the remainder of EU energy and climate legislation, is estimated in this Impact Assessment to reduce GHG emissions by 2030 by more than 40%, i.e. excluding LULUCF emissions and absorptions by around 45% below 1990 levels and including LULUCF by around 47%²⁹.

Therefore the EU's current 2030 GHG emissions reduction target would be overachieved but the resulting pathway still falls short of a balanced trajectory towards net zero GHG emissions and climate neutrality by 2050. Furthermore this achieved reduction is not anchored in climate legislation and fully dependent on the achievement of the energy targets as well as a number of assumptions regarding other EU and Member State policies.

By 2050, the current policies, based on the current target, would lead to a reduction of around 60% below 1990 (see annex 9.3.3.2) – a significant gap with the EU objective of climate-neutrality by 2050. Additional action will therefore be needed to achieve this objective.

Going further, to 50%-55% reduction compared to 1990 levels, including LULUCF emissions and absorptions, would allow to better anticipate the change to come and steer further investment decisions in the right direction.

A 55% reduction would even see slightly higher annual reductions up to 2030 than afterwards to achieve net zero GHG by 2050. Assessing such a profile compared to a pathway that achieves 50% GHG reductions by 2030 allows to assess if there are still low cost reductions options

²⁹ And including intra EU aviation and navigation

available that can be achieved early on, and how it would prepare for deep decarbonisation after 2030.

Increased ambition increases clarity on the pace of emission reductions required and reduces the risk of carbon lock in for new investments. An example is the energy infrastructure assets required to reach climate neutrality, which are characterised by long lead times for construction and decades-long operational lifetime. It will stimulate deployment of new technologies and ramp down technology cost, as it did for solar and wind energy deployment in the context of the 2020 renewable energy targets and more recently for battery technologies in the context of CO₂ and cars Regulations. It will require decision makers to focus on how to achieve net zero GHG emissions, increasing the role of carbon removals in our economy. In this context it is important to take into account the long lead times in land use change, notably for the development of large scale sustainable afforestation and restoration of habitats.

Conversely, the current legislated pathway has not fully incorporated the climate ambition increase for 2050 and risks delaying action, putting in jeopardy the achievement of climate neutrality in 2050. This can be also suboptimal in terms of clean energy transition - as both efforts and benefits of clean energy transition would be postponed.

An additional issue related to the regulatory climate framework is that it presently does not cover all sources of GHG emissions, while the objective of climate neutrality by 2050 is an economy-wide objective, encompassing all emissions.

The current regulatory framework that sets the at least 40% GHG target includes all aviation emissions. Nevertheless, it effectively regulates only emissions from intra-EEA aviation pending international developments (notably ICAO's CORSIA programme). While emissions from EU's international maritime bunkers, a growing sector, is being monitored, reported and verified, they are not covered by the EU ETS.

In this context the relationship between EU action and international action is of importance and can be of relevance for both intra EU and extra EU maritime and aviation activities, supporting and complementing one another. The International Maritime Organisation (IMO) is working on global efforts to address climate change, and the EU is actively supporting this cooperation at international level. For aviation both incoming and outbound flights to non-EEA countries, are not currently priced under the EU ETS, in accordance with the "stop the clock" provision in the ETS Directive intended to provide momentum for a global market-based mechanism – the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) – aimed at compensating the growth of international aviation emissions through international credits. As laid down in the EU ETS Directive, the EU ETS will revert to full scope as of 1 January 2024, unless otherwise revised.

The EU will need to decide how it will want to regulate all emissions, notably related to extra EU aviation as well as intra and extra EU maritime navigation, and decide which part of these emissions it will include in the scope of its own GHG reduction target. Depending of the scope of the GHG target this will impact the overall level of domestic climate action and the associated energy system actions required.

2.2 The 2030 climate and energy policy framework requires updating

The climate target forms part of the wider climate and energy policy framework, which works best when it is internally coherent and in concert with other sectoral policies. This policy framework had been adopted before the EU agreed to pursue the climate-neutrality by 2050, and,

as mentioned above, does not drive action sufficiently, both in terms of scope and timing, to reach this objective.

2.2.1 *Review of climate legislation*

The EU Emission Trading Directive (ETS)³⁰, the Effort Sharing Regulation (ESR)³¹ and the Land Use, Land Use Change and Forestry (LULUCF) Regulation³² combined regulate how many emissions the EU economy can emit and presently only ensure GHG emissions reduce by at least 40% by 2030 compared to 1990.

To achieve a higher climate ambition of 50% to 55% GHG reductions by 2030 all three pieces of legislation will need to be fully updated in a coherent manner to achieve combined a higher ambition level.

In this context there is a specific question related to the role of carbon pricing. The EU Emissions Trading System is the EU's key carbon pricing instrument and the largest emissions trading system in the world. It covers currently less than 45% of the EU's greenhouse gas emissions, focused on emissions from electricity, combined heat and power, industry, district heating and aviation. The environmental outcome as a cap and trade system is guaranteed by its absolute limit on emissions, i.e. the cap.

It needs to be looked at if the introduction of emissions trading, for instance through the extension of the EU ETS, could be used more extensively in sectors such as building heating and road transport, where emissions are more dispersed across a multitude of sources, carbon pricing at national level is often absent or limited and where there are more market failures.

Any decision on expanding the role of emission trading has consequent impacts on other regulatory tools such as the ESR.

Besides emission trading, also taxation could be applied to introduce carbon pricing. The Energy Taxation Directive (ETD)³³ which lays down the EU rules for the taxation of energy products has not changed since 2003 and is outdated and will be reviewed^{34,35}.

2.2.2 *Contribution of renewable energy and energy efficiency legislation*

Currently the combined impact of the energy efficiency and renewable energy targets with climate legislation results in a higher estimated reduction of GHG emissions than what the

³⁰ Directive (EU) 2018/410 amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments, and Decision (EU) 2015/1814

³¹ Regulation (EU) 2018/842 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013

³² Regulation (EU) 2018/841 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU

³³ Directive 2003/96/EC

³⁴ <https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12227-Revision-of-the-Energy-Tax-Directive>

³⁵ The revision of the Energy Taxation Directive and introduction of a Carbon Border Adjustment mechanism are only one element to be introduced in a context of much broader tax reforms. Environmental taxation (and emissions trading) can not only incentivise behavioural change, but can also raise revenues, contribute to addressing inequality issues and ensure a level playing field. It is within this context that the Commission has identified a need for broad based sustainable fiscal reforms shifting from labour taxation to pollution as the Green Deal calls for.

climate legislation in isolation is meant to achieve. This combined impact is estimated at around 45% below 1990 levels excluding LULUCF³⁶.

By contributing currently just over 75% of total GHG emissions in the EU, including the non-CO₂ emissions from the energy system, the energy sector is central to the achievement of the higher climate target and its role needs to be reviewed to achieve higher climate ambition of 50% to 55% GHG reductions by 2030.

There is currently unaddressed potential for the further very significant deployment of renewable energy necessary to reach climate-neutrality. Market barriers and lack of incentives, particularly in end-use sectors such as heating and cooling or transport, hinder further penetration of renewables, either through electrification, or via the penetration of renewable and low-carbon fuels such as advanced biofuels and renewable and other sustainable alternative fuels and gases. An integrated approach to develop and deploy further renewable technologies like offshore wind energy and other is missing. Enhanced and expanded measures under RED II could deliver a larger uptake of renewable energy in the EU.

Energy efficiency is a key avenue of action, without which full decarbonisation of the EU economy cannot be achieved. There is a considerable potential for enhanced and expanded measures under the EED that could deliver higher savings. While in all sectors energy efficiency potential remains large, there is a particular challenge related to the renovation of the EU building stock, with a 75% share of building stock that has a poor energy performance and thus contributes significantly to emissions. The transition to climate neutrality cannot be achieved if no significant step up of renovation rates and depth is achieved which will be looked at in detail in the Commission's upcoming Renovation Wave initiative. The energy efficiency first principle, recently included in the energy legislation, is still far from being fully exploited and applied in all relevant sectors. Finally, policy initiatives that aim at facilitating investments, reducing their perceived risks, increasing the effectiveness in the use of public funding or helping mobilise private financial resources could also play a stronger role.

A decarbonised energy system will require more sector integration going beyond electrification that is mentioned above. In order to meet increased climate ambition, further deployment of renewable and low-carbon fuels, notably clean hydrogen, will be needed which will require a suitable internal market framework. The EU strategies on Energy System Integration and on Hydrogen look in more detail into necessary actions.

More broadly, moderate and uneven efforts in terms of energy system integration, uptake of electricity and other low-carbon energy carriers such as advanced biofuels, hydrogen or e-fuels, carbon capture and storage (CCS) and CCU technologies, especially if compounded with lack of dedicated energy infrastructure and markets, negatively affect the pathway to climate neutrality, especially the decarbonisation of industry or the transport sector (notably aviation and maritime navigation which have limited number of decarbonisation options available)³⁷.

³⁶ And including intra EU aviation and navigation

³⁷ These technologies need to be tested at scale, and through increased deployment cost reductions need to be achieved just like was done for intermittent renewable energy. While policies exist such as the EU's Innovation Fund, this will require continued focus with pull and push policies, including the development of lead markets for climate neutral industrial products.

2.2.3 *Difficult to abate emissions in the transport sector*

The transport sector is a particular challenge. Options to decarbonise exist, but will require infrastructure development at local and EU scale (e.g. charging stations, hydrogen fuel stations). Modal shift, increased use of inland waterway transport and rail and new forms of urban mobility are all part of the solution. But some hard to abate sub-sectors, notably aviation, will also require the development of advanced biofuels and sustainable alternative low or zero carbon fuels and gases. To address specific challenges of the transport sector the Commission will propose a comprehensive strategy on ‘Sustainable and Smart Mobility’. This strategy will build on the other Green Deal initiatives and actions that the Commission already deployed for the recovery of the sector, with a view to contributing to the increased EU 2030 climate target, clean energy transition and climate neutrality by 2050.

More background on elements of importance for coherence when developing energy, climate and transport policies is provided in annex 9.10.2.

2.2.4 *Land use emissions*

The transition will also result in increasing demand for biomass, be it for alternative uses in products or bio-energy, while at the same time the EU land use sink needs to be maintained and enhanced and EU biodiversity safeguarded. Inclusion of the net LULUCF sink when assessing GHG emission reductions and climate ambition is required to assess progress towards achieving net zero GHG emissions. This will require careful planning and policies for sectors with long lead times such as forestry.

2.2.5 *Non-CO₂ emissions*

Non-CO₂ emissions, notably from agriculture, waste and industrial sectors, represent currently just below 20% of the EU’s GHG emissions. Under the current policies, they are projected to continue to decrease but more efforts will be needed for achieving climate neutrality. Taking into account that by 2050 agriculture non-CO₂ emissions will be the single largest emission source, limiting these as much as possible will limit the need for CO₂ removals.

2.3 Expected evolution based on current policies

Efforts proposed so far by Member States in their NECPs fall short of the EU energy efficiency target for 2030, even if the two other targets of the current 2030 climate and energy framework (GHG emissions and renewable energy) are to be met or even slightly overachieved.

More than 10 Member States announced a coal phase-out before 2030 and renewables will develop strongly in power generation in most of the countries (which led several of them to put forward ambitious contributions). Most Member States reported, in their Long-Term Renovation Strategies, a good mix of measures aimed at building renovation and a fuel switch; however, a preliminary analysis suggests that actual renovations not always reflect the full energy savings potential of the building stock. Moreover, a particular challenge stems from energy use in the transport sector that saw emissions increasing compared to 1990³⁸.

³⁸ Road transport emissions actually reduced over 2007-2013, but this trend reversed since due to notably the drop in oil prices. Source; EEA GHG data viewer.

Thanks to the mechanisms foreseen in the Governance Regulation, all three 2030 targets are expected to be met nonetheless, though this would require intensive efforts throughout the period. It is, however, unlikely that higher levels of energy efficiency and renewable deployment by 2030 (as needed for an increased climate target) would be achieved thanks to market forces, current market organisation³⁹ and technology development alone.

The ETS market balance under the cap as currently defined may be challenged by the combined effect of reduced emissions early on due to the COVID-19 crisis and a continued emissions profile well below the cap if other policies effectively deliver the existing 2030 energy efficiency and renewable energy targets. From a market functioning point of view, this is not optimal, in the longer term possibly affecting the ability of the ETS to meet more demanding emission reduction targets cost-effectively if the Market Stability Reserve is not reviewed in 2021.

The achievement of the national GHG reduction targets under the Effort Sharing Regulation will require continued strengthening of policies or the use of flexibility mechanisms in a number of Member States.

Regarding the non-CO₂ emissions, three sectors dominate methane and nitrous oxide emissions, i.e. energy, waste and agriculture. This makes them significant in view of the climate-neutrality objective.

EU energy related methane emissions will continue to decrease due to a continued reduction in consumptions and extraction of fossil fuels in the EU. However, preventing gas leakages is important, also to ensure the sector's environmental integrity when clean gases progressively replace fossil gases.

In the waste sector, successful policies are in place that will continue to reduce emissions, by avoiding as well as capturing and using emissions from landfilling. Their focus is shifting towards waste as a material resource. Achieving circularity will thus not only reduce the need for disposal of remaining waste streams, it will also reduce the primary resource intensity of our economy and with it the associated industrial and energy emissions. Delivering on this is an integral part of the European Green Deal, as stressed in the Circular Economy Action Plan⁴⁰, but is not ensured under current legislation.

The sector where a reduction of non-CO₂ emissions is most challenging is the agriculture sector. Current policies need to be accompanied by ambitious implementation of the national CAP strategic plans, requiring Member States to focus on increased environmental ambition. The absence of such ambition will result in a stagnation of non-CO₂ emissions of the sector. While EU farming is seen as relatively efficient overall, nutrient losses and over-application of fertiliser certainly still constitute a large source of non-CO₂ emissions that can be substantially reduced, as also recognised in the Biodiversity Strategy⁴¹. While technologies and practices to reduce emission exist, it cannot be expected that the agriculture sector itself will deploy them without additional policies.

Left without a revised policy framework, the net removal of CO₂ from the atmosphere by the LULUCF sector in the EU will at best remain stable – or even decrease in the EU due to

³⁹ Importantly, regulatory barriers still exist and may prove hampering our decarbonisation efforts. Removing them will render the decarbonisation pathways possible, and with more competitive and more liquid markets integrated across energy carriers, infrastructures and consumption sectors will help us to achieve climate neutrality in cost effective way.

⁴⁰ https://ec.europa.eu/environment/circular-economy/pdf/new_circular_economy_action_plan.pdf

⁴¹ COM(2020) 380 final

structural evolution of forests. This is in itself a real problem since an EU climate-neutral economy will require a substantial amount of nature-based solutions to remove CO₂ to compensate any remaining GHG emissions. Furthermore, climate change accentuates the risk for ecosystems. Droughts could increase the loss of soil carbon. Hazards such as storms, pests or fires can cause more emissions. Difficult to project, these could deteriorate the functioning of the natural sink.

Following widespread calls for more ambitious climate action throughout European civil society, industry and consumers are increasingly conscious about their carbon footprint and the need to reduce it. Emerging trends such as reduced meat consumption, train travel to substitute for short-haul flights, and increased videoconferencing for business meetings are all trends that point towards demand-driven reductions in GHG emissions. Some of these may be encouraged by the impact of the COVID-19 crisis, such as teleworking. Taken together, however, these behavioural trends are not strong enough by themselves to bring EU climate ambition in-line with climate neutrality.

The EU's and its Member States' efforts to reach the climate-neutrality objective may be impacted by the effects of the COVID-19 crisis. While greenhouse gas emissions fell strongly in the first half of 2020 as a result of a slowdown in economic activity, it is currently unclear what the mid- to long term impact of the crisis on economic growth and emission profile will be and what can be expected in terms of change in energy demand pattern. On the one hand it is highly likely that the future emission profile has been impacted downward. On the other hand the potential for investment by the private sector is certainly dented, while of crucial importance to deliver the increased investments needed to achieve a climate neutral transition. There is a broad consensus that green growth is beneficial for a sustainable economic recovery and the recovery plans offer a chance to redirect investments away from GHG-emitting activities, thus changing the emissions intensity of the EU economy. This is captured in the Commission's recovery package as per the Communication on 'Europe's moment: Repair and Prepare for the Next Generation'⁴².

For a more detailed discussions on the potential implications impact of the COVID-19 crisis see annex 9.10.1.3 and on the role of the EU recovery package see section annex 9.11.1.

Summing up, the analysis of various policy developments shows that the current policies are insufficient for the EU to reach the 2050 climate neutrality objective.

⁴² COM(2020) 456 final

3 WHY SHOULD THE EU ACT?

3.1 Legal basis

According to Article 11 of the Treaty on the Functioning of the European Union (TFEU), environmental protection requirements must be integrated into the Union's policies and activities, in particular with a view to promoting sustainable development. Articles 191 to 193 of TFEU further clarify that policy preserve, protect, and improve the quality of the environment; protect human health; and promote measures at the international level to deal with regional or worldwide environmental problems. Article 191 mentions climate change as one such problem in particular.

3.2 Subsidiarity: Necessity of EU action

Climate change is a trans-boundary problem. For trans-boundary problems, individual action is unlikely to lead to optimal outcomes. Instead, coordinated EU action can effectively supplement and reinforce national and local action. Coordination at the European level enhances climate action and EU action is thus justified on grounds of subsidiarity in line with Article 191 of the Treaty on the Functioning of the European Union.

3.3 Subsidiarity: Added value of EU action

The coordination of the reduction of greenhouse gas emissions across the European Union benefits from coordination at the EU level given the EU's single market. In this particular Impact Assessment, an increase in the 2030 target for EU GHG reductions will impact most sectors across the EU economy. The increase may furthermore require policy responses in many fields, including beyond climate and energy policy itself. The impacts of such ambition increase and related policies on growth and jobs creation, fairness and cost-effectiveness are examples of elements that can be better considered at the EU level.

Action at the EU level is therefore indispensable and coordinated EU policies have a much bigger chance of leading to a true transformation towards a climate neutral economy by 2050. Coordinated action at the EU level furthermore facilitates the full consideration of the different capabilities to act among Member States. The EU single market moreover acts as a strong driver for cost-efficient change.

EU-level climate policy finally adds significant value for international climate action. Since 1992, the EU has worked to develop joint solutions and drive forward a global agreement to fight climate change. These efforts have helped to achieve the Paris Agreement in 2015. International climate policy and climate diplomacy have been strengthened as a result of coordination of European climate policy at the EU level, both of which are crucial in a world in which the EU accounts for only around 10% of global GHG emissions.

4 OBJECTIVES: WHAT IS TO BE ACHIEVED?

4.1 General objectives

The European Green Deal has a particular focus on making Europe the first climate neutral continent (i.e. achieve net GHG emissions to zero by 2050). It indicated inter alia that the Commission would come forward with a 2030 Climate Target Plan.

In line with the two aspects of the problem identified in section 2, the first general objective of this initiative is to increase the EU's greenhouse gas emission reductions target to 50% to 55% by 2030 compared to 1990 and determine the scope of the target in order to put the EU on a balanced, credible and realistic track to achieve its objective of climate neutrality by 2050 and provide stakeholders with increased predictability.

As such, the plan will also propose the starting point of the trajectory for achieving climate neutrality as set in Article 3 of the European Climate Law proposal⁴³ (see also section 1.2).

As indicated in section 2, in order for the EU to achieve the objective of climate-neutrality, the policy architecture for climate, energy, transport and other policies will need to be strengthened in a coherent manner. Therefore, the second general objective of this initiative is to prepare the ground for the necessary adaptation of the policies playing a key role in the decarbonisation of the European economy.

4.2 Specific objectives

The general objectives described above are divided into the following specific objectives:

Outline how all sectors of the EU's economy need to contribute to achieving the increased GHG target, including sectoral abatement of CO₂ and non-CO₂ emissions as well as emissions and absorptions by the LULUCF sector. The Plan will thus look into cost-efficient sectoral potentials for decarbonisation related the increased GHG target in order to identify the possible repartition of further efforts.

Prepare the ground for which parts of the climate and energy policy framework, including a potentially extended role of carbon pricing and emission trading, need to be revised. The specific relevant pieces of climate and energy legislation are:

- the Emissions Trading System Directive (ETS)⁴⁴;
- the Effort Sharing Regulation (ESR)⁴⁵;
- the Renewable Energy Directive⁴⁶;
- the energy-efficiency policy framework, notably the Energy Efficiency Directive⁴⁷;
- CO₂ Emissions Performance Standards for Cars and Vans⁴⁸;
- The Land Use, Land Use Change and Forestry Regulation (LULUCF Regulation)⁴⁹.

⁴³ https://ec.europa.eu/clima/policies/eu-climate-action/law_en

⁴⁴ Directive (EU) 2018/410 amending Directive 2003/87/EC

⁴⁵ Regulation (EU) 2018/842.

⁴⁶ Directive (EU) 2018/2001 (recast of Directive 2009/28/EC).

⁴⁷ Directive 2012/27/EU as amended by Directive (EU) 2018/2002.

⁴⁸ Regulation (EU) 2019/631.

⁴⁹ Regulation (EU) 2018/841.

The same approach applies to transport specific policies and the need for their revision in the context of the increased GHG target.

Considering the central role of the energy sector in the decarbonisation of the economy, the Climate Target Plan will reflect on the interplay between the GHG reduction target and the ambition for renewables and energy efficiency in 2030. In particular, it will investigate if current overall ambition of renewables and energy efficiency policies is sufficient to deliver an increased GHG target.

4.3 Impacts assessed

The Plan will explore how to achieve these objectives in a responsible manner, taking into account issues such as:

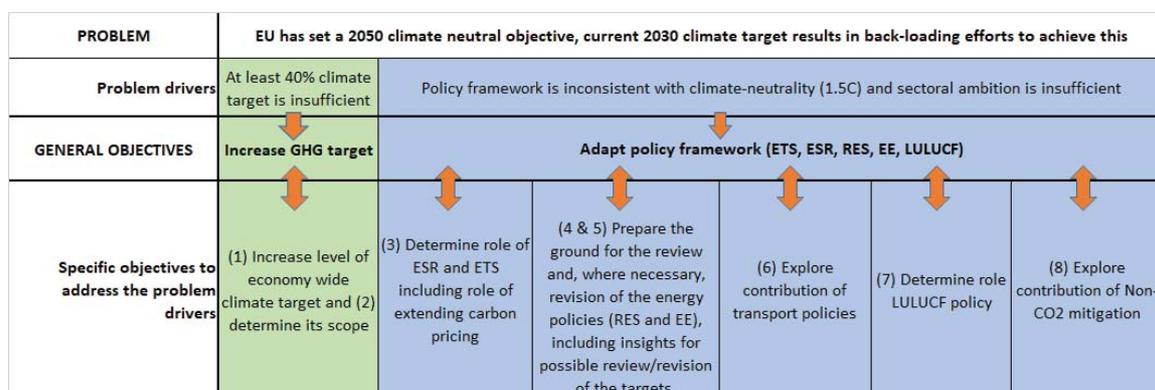
- contribution to economic growth and prosperity, taking into account the impact of the COVID-19 crisis;
- how to do so in a socially just manner, leaving no one behind;
- consistency with a secure, affordable and sustainable energy system;
- avoidance of the risk of carbon leakage;
- contribution to technological progress in the EU and earning an early leadership in clean and energy-efficient technologies;
- contribution to a sustainable transition in the broadest sense, including efforts to protect and restore biodiversity and ecosystems, the reduction of air pollution, the sustainable use of natural resources and ensuring food security;
- the need for a proper enabling framework to ensure the confidence of actors and building on the strengthening of synergies across all policy areas.

The 2030 Climate Target Plan will allow for a societal and political debate on the merit of adopting this increased ambition and thus inform also the subsequent assessment and development of legislative policy proposals planned for June 2021.

4.4 Intervention logic

Figure 2: shows the intervention logic of this Impact Assessment, from the problem and problem drivers to the objectives. The policy options described in section 5 are defined to address these objectives.

Figure 2: Intervention Logic



5 WHAT ARE THE AVAILABLE POLICY OPTIONS

This Impact Assessment analyses two types of policy options related to the:

1. overall increase of ambition of GHG emissions reductions for 2030;
2. need for adaptations of the policy architecture to achieve such increased GHG ambition.

The policy options correspond to the problems this initiative aims to address and its objectives as presented in section 4.4.

As regards the climate ambition, the options look at the level of net GHG emissions reductions (thus including LULUCF) in 2030 compared to 1990 of 50 or 55% and what the impact is from retaining extra EU aviation or not and of including intra and extra maritime navigation in this target.

The analysis is sufficiently detailed to inform a decision proposing (i) the new 2030 GHG reduction target, (ii) the starting point of the trajectory for achieving climate neutrality as set in Article 3 of the European Climate Law proposal (see also section 1.2) and (iii) the appropriate level of EU ambition for renewable energy and energy efficiency in 2030.

The Impact Assessment will also inform political decisions as regards to the priority areas for the legislative initiatives to be adopted by June 2021, in order to achieve the overall ambition in a coherent manner. Therefore, the policy options relate also to:

- various levels of intensification of policies in the field of renewables, energy-efficiency, transport and non-CO₂ emissions;
- possible extension of carbon pricing and emissions trading versus intensifying the existing regulatory toolbox,
- flexibility of the Land Use Land Use Change and Forestry Regulation,

Given the magnitude of the policy changes needed in order to implement the increased climate target in a coherent manner, this Impact Assessment does not discuss precise sectoral ambitions or detailed policy tools required. These will be addressed in a series of detailed specific impact assessments accompanying proposals of legislative acts to be prepared in a coherent and coordinated manner and adopted by the Commission by June 2021.

5.1 What is the baseline from which options are assessed?

The baseline for this assessment is the existing 2030 climate and energy legislative framework. It consists of the agreed climate and energy targets as well as the main policy tools to implement these. It is referred to in section 6 as the baseline (BSL).

The baseline includes the climate legislation that implements the ‘at least 40% GHG target’. Notably the revised ETS directive⁵⁰ which regulates GHG emissions mainly from the power and industry sectors plus aviation, the Effort Sharing Regulation⁵¹ that sets national targets for emissions outside of the ETS and the LULUCF Regulation⁵².

For energy it includes achieving the targets of at least 32.5% energy efficiency and 32% of renewable energy share in the energy mix. These are implemented through the Energy Efficiency

⁵⁰ As amended by Directive (EU) 2018/410

⁵¹ Regulation (EU) 2018/842

⁵² Regulation (EU) 2018/841

Directive and the Renewable Energy Directive⁵³ as well as other key policies covered in the Energy Union and the “Clean Energy for All Europeans” package, including internal electricity market policy⁵⁴. This includes the Governance Regulation that requires Member States to prepare National Energy and Climate Plans covering, for the first period, the years 2021-2030 and allows an update in the years 2023/2024.

On transport, the baseline includes measures from the three European Commission “Mobility Packages” published⁵⁵ in 2017-2018. Key measures include CO₂ standards for cars and vans⁵⁶, as well as trucks⁵⁷, the Alternative Fuels Infrastructure Directive⁵⁸, the Clean Vehicles Directive⁵⁹, and the Eurovignette Directive⁶⁰

The impact of the baseline is projected with the PRIMES – GAINS – GLOBIOM modelling tools in the BSL scenario. This allows to see interactions economy-wide for all sectors that emit and absorb emissions in a coherent manner. For a detailed description of the policies included in the BSL, see annex 9.3.3.1.

The BSL is built on economic assumptions from before the COVID-19 crisis that heavily impacted the EU economy and therefore the economic projections made in preparation for this Impact Assessment. The situation is still evolving and the eventual outcome uncertain. Nevertheless it is important to assess, based on the best information currently available, the possible impact of the COVID-19 crisis on the 2030 Target Plan and the role the recovery package can have in stimulating green investments. Therefore, a sensitivity run COVID-BSL was performed that complements the baseline (BSL).

What can be noted is that in relation to achieved GHG reductions and energy efficiency and renewable energy ambition by 2030, there is relatively little difference between BSL and COVID-BSL, given that both scenarios assume full achievement of the existing targets by 2030. For more details related to this COVID-BSL scenario, see section 6.4.3 and annex 9.3.3.2.

Next to the BSL scenario, a variant (EU-NECP) was developed which in a stylised manner reflects to the extent possible the aggregate ambition of the final National Energy and Climate Plans that Member States submitted according to the Governance Regulation⁶¹. Having in mind the time constraints, this analysis has limitations, had to be simplified for the modelling purposes and does not reflect the full range of future foreseen national policies and measures.

Table 1 gives an overview of the key climate and energy results of the BSL scenario and the EU-NECP variant.

⁵³ Directive (EU) 2018/2001

⁵⁴ The adopted regulation on the electricity market design are addressed is reflected to the extent possible. However, the modelling work undertaken is not detailed enough to draw conclusion on the adequacy specific elements of the current market design. Such issues will require further analysis in a dedicated study.

⁵⁵ See for links to the different policy initiatives: https://ec.europa.eu/transport/modes/road/news/2018-05-17-europe-on-the-move-3_en

⁵⁶ Regulation (EU) 2019/631

⁵⁷ Regulation (EU) 2019/1242

⁵⁸ Directive 2014/94/EU

⁵⁹ Directive (EU) 2019/1161

⁶⁰ COM(2017) 275 final, proposal to amend Directive 1999/62/EC

⁶¹ Regulation (EU) 2018/1999

Table 1: Key indicators for 2030 baseline scenarios

	Total GHG vs 1990 (including intra EU aviation and navigation)		Overall renewable energy share ⁶²	Energy savings ⁶³	
	Excluding LULUCF	Including LULUCF		Primary energy consumption ⁶⁴	Final energy consumption ⁶⁵
BSL	-45.1%	-46.9%	32.0%	-34.2%	-32.4%
EU- NECP variant	-44.4%	-46.2%	33.5%	-32.0%	-29.5%

The BSL scenario basically reaches the final energy consumption efficiency target for 2030 (32.5%) and reduces the primary energy consumption beyond this level (34.2%). This difference, which was not present when assessing the baseline for the Long Term Strategy, results to a large extent from the evolution of the power sector. It is now projected that increasing electricity demand (through electrification of transport and heating) will be met with more efficient capacities being commissioned (in particular wind and solar) while less efficient ones will decrease over time (notably coal-fired generation will decline strongly driven by national policies on coal phase out foreseen in the NECPs).

These changes in the primary energy consumption in turn drives increased GHG reductions., resulting in a reduction of EU GHG emissions, excluding LULUCF and including all intra EU aviation and navigation, of 45.1% by 2030 compared to 1990. This is a somewhat higher reduction than for the baseline projections as used in the analysis for the Long Term Strategy (LTS Baseline).

This LTS Baseline projected for the EU28 and for a GHG scope that excluded LULUCF but included intra + extra EU aviation a reduction by 2030 of 46.0%. For EU27, the reduction in the LTS Baseline was more limited at 43.5% for the same scope. The updated BSL used in this assessment estimates now for that same scope the reduction of 44.0% GHG emissions by 2030. Therefore this assessments projects around 0.5 percentage point (p.p.) greater reduction in baseline scenario than was the case for the Long Term Strategy⁶⁶. The principal driver seems to be the shift towards greater reduction of primary energy consumption that is required to achieve the overall energy targets.

Including net LULUCF, and including intra EU aviation and navigation emissions, emissions decrease by 46.9% by 2030 compared to 1990. LULUCF emissions and absorptions are included in a conservative manner, based on projections that follow the “No Debit” assumptions as under the current LULUCF regulation (see also section 6.2.3).

While BSL, by construction, achieves the 2030 targets of at least 32.5% energy efficiency and 32% of renewable energy share in the energy mix, the EU-NECP variant over achieves renewable energy target (achieving 33.5% RES share in 2030) in line with findings on the EU

⁶² Share of RES in gross final energy consumption according to 2009 RES Directive.

⁶³ Energy Savings evaluated against the 2007 Baseline projections for 2030.

⁶⁴ It corresponds to the EUROSTAT indicator PEC (2020-2030)

⁶⁵ It corresponds to the EUROSTAT indicator FEC (2020-2030)

⁶⁶ The LTS Baseline used global warming potentials (GWPs) of the 4th Assessment Report of the IPCC to transform non-CO₂ emissions into CO₂-equivalent emissions. This assessment uses instead GWPs of the 5th Assessment Report which starting with 2021 emissions will be used in both the UNFCCC greenhouse gas inventories and EU legislation (see also COMMISSION DELEGATED REGULATION (EU) 2020/1044 supplementing Regulation (EU) 2018/1999 with regard to values for global warming potentials). This affects additional GHG reductions in BSL projections very slightly, at a magnitude of 0.1% additional GHG reductions by 2030.

collective RES ambition that results from the final NECPs. It thus performs better than the BSL scenario.

Conversely, the EU-NECP variant, achieving 29.5% reduction in final energy consumption, projects an underachievement and thus a gap to the agreed 2030 energy efficiency target (on final energy consumption). This is also in line with the findings on the EU collective EE ambition that results from the final NECPs.

Primary energy consumption reduction projections in EU-NECP variant (32%), however, are close to the agreed target for 2030. This is not in line with the assessment of the MS collective ambition in the final NECPs which indicates that the gap in final energy consumption is mirrored by the gap in primary energy consumption. This modelling result of EU-NECP variant follows the PRIMES projections in the BSL that capture the latest evolutions in the power generation, notably coal phase-out (not fully reflected in the NECPs) and the latest technology outlook for renewables in power generation.

Combined, both the high RES and primary energy consumption ambition of the EU-NECP variant result in a GHG emission reduction of 44.4% reductions excluding LULUCF. Excluding international maritime navigation but including intra and extra EU aviation emissions this scenario achieves 43% reductions. This is a bit higher than what findings of the EU aggregate of final Member States' NECPs result in (41% GHG reductions for the same scope).

Overall, these projections both confirm that the EU can be expected to overachieve its NDC of at least 40% domestic GHG reductions, also without the UK, if implementing fully its existing legislation.

For a more detailed overview of the BSL results, see Annex 9.3.3.2.

For assessing the impacts of increases in climate ambition this Impact Assessment compares to the BSL scenario, representing the legislated current targets, and shows impacts over time.

The Commission is still in the process of assessing at Member State level the final NECPs. This together with the ongoing periodic update of the EU Reference Scenario on energy, transport and GHG emissions (see annex 9.3.2) will allow to further improve and enrich the modelling with a view of future impact assessments supporting the future implementation of the 2030 Climate Target Plan.

5.2 Description of the policy options

5.2.1 Policy options related to ambition

5.2.1.1 Policy options related to the scope of the GHG target

In order to interpret ambition levels for greenhouse gas emissions and the associated ambition for energy efficiency and renewable energy, it is necessary to define the scope on which the GHG target applies. There are various reasons to reconsider the scope of the EU greenhouse gas target. This concerns both how to include the LULUCF sector as well as international maritime and extra-EU aviation emissions.

The LULUCF sector can contribute to the EU's 2020 target under the Kyoto Protocol, by applying a number of accounting rules on the LULUCF inventory. This contribution is presently substantial under the Kyoto Protocol. The 'accounted' sink produced for 2013-2017 an annual average -111.9 MtCO₂-eq credits that can be used to track progress to achieve our Kyoto Protocol 2020 target of at least 20% GHG reductions.

This approach is continued under the EU's National Determined Contribution (EU NDC) under the Paris Agreement, which a target to achieve at least 40% GHG emission reductions domestically compared to 1990 by 2030. The EU land use, land use change and forestry (LULUCF) sector can contribute to the at least 40% GHG target under the EU NDC, but accounting is applied. Under the LULUCF regulation applicable from 2021 onwards the accounting rules were made more stringent compared to the current Kyoto Protocol rules. The focus is to ensure that credits are only generated in sub-sectors and activities where the LULUCF sink performs better than historically reported for each of the different land activities. The credit amount is projected to decrease if no additional policies are undertaken to maintain the sink, due to the impact of age classes in our forests and probable resulting increased harvest rates.

The achievement of the NDC is ensured through EU legislation. The EU ETS and ESR define a -40% greenhouse gas reductions target for all sectors with net emissions, including international aviation. The LULUCF sector, which sees net removals, is not included in the ETS and ESR coverage. However, in case the LULUCF sector performs better than what is expected under current management practices (the so-called accounted sink), a limited flexibility in the form of credits is available for Member States to use towards their ESR target. If not, any LULUCF debits would need to be covered by ESR emission allocations. Combined, this legislation ensures the EU will meet its NDC target.

The accounted LULUCF sink does not represent the full size of the sink. The full size of the sink matters when establishing if the EU is on track or not to achieve net zero GHG emissions by 2050. This requires that any remaining greenhouse gas emissions will be fully absorbed by a corresponding sink, which to a large extent will have to come from the LULUCF sink. The analysis in support of the Long Term Strategy indicated the natural LULUCF sink will need to be maintained or expanded.

Thus to track progress towards climate neutrality the full net LULUCF sink needs to be included when looking at GHG ambition. Therefore in this Impact Assessment the full scope of the net LULUCF sink is included in all assessments to assess if 50% to 55% GHG reductions are achieved by 2030 and see its changes over time, from 1990 to 2030 and onwards to 2050 to achieve net zero GHG emissions.

This metric that includes the full scope of the LULUCF sink is also applied in global modelling tools to assess mitigation pathways and corresponding temperature goals (see also annex 9.10.6).

International navigation emissions are presently not included at all in the GHG target scope, not even for movements between two EU Member States. It has to be considered how to include them in the EU target ambition. The International Maritime Organisation (IMO) is discussing further steps to address GHG emissions from maritime navigation to implement its initial Strategy on reduction of GHG emission from ships. The Strategy's current target of at least 50% emission reductions by 2050 falls short of EU ambition. While the EU will advocate for a strengthening of the target as part of the IMO GHG Strategy's revision in 2023, the EU needs to already consider now which instruments and policies it will implement to stimulate GHG reductions of this sector. This includes deciding on how it will include the sector in its GHG target, whether a differentiation should be made on how to regulate between intra-EU ship movement and extra-EU ship movement, and relating this to the analysis for extending European emissions trading to the sector.

While international aviation is fully included in the EU ETS, the current international context has led the EU to temporarily limit the scope of the EU ETS to flights between two EEA member states. Presently the EU is thus not actively controlling all these emissions. In 2016, ICAO agreed on a global market based mechanism aimed at compensating the growth of international CO₂

aviation emissions beyond 2020 (CORSIA), and the last steps for it to become operational are being taken in ICAO. CORSIA rests on the use of international credits, which therefore would not translate into domestic EU reductions.

Therefore this Impact Assessment looks at the following options:

Option Scope_1: Current scope (baseline)

This option is the Baseline, and includes domestic and international aviation emissions but not maritime navigation emissions to the EU GHG target of at least 40% GHG.

Option Scope_2: Including intra-EU bunker fuel emissions

In this option, the scope of the target to reduce emissions domestically is adjusted to include all emissions due to international aviation and international maritime voyages between two EU member states, but not between the EU and locations outside of the EU, the so-called extra-EU aviation and extra-EU maritime navigation emissions.

Option Scope_3: Including all EU bunker fuel emissions

In this option the scope of the target to reduce emissions domestically is adjusted to include all aviation and maritime voyages between EU Member states (intra-EU), as well as 50%⁶⁷ of all emissions due to incoming and outgoing aviation and maritime⁶⁸ voyages between the EU and third countries (extra EU).

As these emissions are growing fast, achieving an EU GHG target domestically of respectively 50% and 55% by 2030 is more demanding on the domestic GHG profile with option Scope_3, than with option Scope_2 that has a more limited coverage of these sectors.

The scenarios presented in section 5.4 include thus mostly scenarios that achieve 50% or 55% GHG reductions with GHG scope as in option Scope_2 as well as one scenario representing option Scope.3.

All scenarios present the results including the full net LULUCF sink to establish if the EU achieves 50% to 55% GHG reductions and is on track or not to achieve net zero GHG emissions by 2050.

5.2.1.2 Policy options related to the level of the climate target and interaction with energy policy

This chapter puts forward the options assessed regarding the ambition level to increase the 2030 GHG emissions reduction target for the EU. The options on 2030 GHG target follow the mandate that the Commission has established in its Political Guidelines and the European Green Deal Communication: i.e. an increase of GHG emissions reductions in 2030 (from “at least” 40% currently agreed) to “at least” 50% to 55% (compared to 1990 levels).

⁶⁷ Given that this concerns movements between the EU and a non-EU country, it is assumed the EU is only responsible for half of the related emissions for any possible target definition with the other country being responsible for the other half.

⁶⁸ For international navigation emissions, analysis in this impact assessment is based on bunker fuels sold in the EU, comparable to the memo item as reported in the EU greenhouse gas inventory reported to the UNFCCC. The emission scope for any regulation that may be based on specific monitoring, verification and reporting requirements is likely to have a less large scope and thus a somewhat reduced impact. This will be analysed in future impact assessments.

The responses to the public consultation, the resolutions of the European Parliament and initiatives of a number of Member States show that there is a broad support on the need to increase 2030 targets for GHG emissions reduction. However, views diverge on what the appropriate level of ambition should be, some of them going even higher than a 55% GHG reduction by 2030. See section 5.3 on a discussion why certain options were not assessed. This Impact Assessment focusses on GHG reductions of 50% to 55% by 2030.

Climate targets (and legislation) work well in concert with energy targets (and legislation). Therefore, the policy options for increasing the GHG target explored in this Impact Assessment are accompanied by options for increasing the ambition levels of energy efficiency and renewable energy deployment.

The results of the public consultation and the dialogue with Member States, the European Parliament and stakeholders clearly show that there is a broad consensus on the need to increase 2030 ambition on energy efficiency and renewable energy. There is, however, a difference of opinions as to which policy tools shall incentivise such higher levels, which is reflected in the policy options presented in section 5.2.2.

Therefore this Impact Assessment explores a number of combinations of increased climate ambition with increased energy policy ambition, to assess their interaction. The policy options considered in this Impact Assessment are:

Option GHG_1: Current EU 2030 GHG target (baseline)

The “Baseline” option, as described in section 5.1 and annex 9.3.3 for this Impact Assessment, consists of the agreed 2030 policies and targets. The core targets are at least -40% reduction in domestic economy wide greenhouse gas emissions by 2030 compared to 1990 with unchanged scope of sectors included in these targets, a share of renewable energy of at least 32% and an increase in (primary and final) energy efficiency of at least 32.5%.

Option GHG_2: Increased 2030 EU GHG target equal to -50% GHG

In order to provide for a more gradual pathway towards the objective of climate neutrality by 2050, the second option reduces greenhouse gas emissions by at least 50% in 2030 compared to 1990.

This is accompanied – in the analysis of impacts - with an increase of ambition of EE and RES levels driven by low intensification of energy and transport policies⁶⁹.

Option GHG_3: Increased 2030 EU GHG target equal to -55%

In order to provide for a more accelerated pathway towards the objective of climate neutrality by 2050, the third option reduces greenhouse gas emissions by 55% in 2030 compared to 1990.

This is accompanied – in the analysis of impacts - with various stylised combinations of policy setups as compared to the baseline:

- in the first policy set-up, renewable energy and energy efficiency policies are not intensified, climate target is achieved by increased use of carbon pricing in energy related non-ETS sectors combined with low intensification of transport policies;
- the second policy set-up assumes medium intensification of energy and transport policies accompanied by an extension of carbon pricing to energy related non-ETS sectors.

⁶⁹ The analysis of this option also assumes an increased role for carbon pricing in the road transport and buildings sectors.

- the third policy set-up assumes high intensification of energy and transport policies and no extension of carbon pricing to non-ETS sectors.

Options 2 and 3 would require changes to the climate legislation (ETS, Effort Sharing Regulation and LULUCF regulation) as well as specific transport legislation. Option 2 and the second and third policy set-up of option 3 would require changes to energy legislation (RED II and EED).

The scenarios presented in section 5.4 illustrate how various combinations of climate and energy policy options can deliver the increased overall GHG ambition. Results of this scenario assessment are discussed in section 6.2 to 6.5 and thus allow to assess potential synergies, overlaps and trade-offs of policy combinations which need to be taken into account when developing policies.

5.2.2 Policy options related to the policy framework

The following sections describe stylised policy options regarding climate and energy policy architecture. Only major issues are addressed by these policy options, i.e. application of carbon pricing beyond the current ETS sector, overall intensification of energy efficiency, renewables and transport policies, intensification, flexibilities and broader scope of the LULUCF legislation. Detailed policy instruments design which are essential for these policy options to be effective and realistic, will be assessed in the future impact assessments accompanying legislative proposals.

For climate policies, the key question is whether to maintain the current architecture and scope of the EU ETS and ESR when increasing GHG ambition or to change some elements of their scope and expand the use of emission trading, and what role the LULUCF regulation plays in maintaining and enhancing the EU's LULUCF sink. Also the role of policies which address non-CO₂ emissions is analysed.

For energy policies, the key question is which policy measures could be included in RED II and EED revisions or in other energy legislation that would deliver medium to high intensification of EE and RES policies as described in section 5.2.1.2. The upcoming review of the EED, and RED II legislation (scheduled for June 2021) will further assess the role of these instruments in delivering an increased GHG target and propose detailed revisions, where necessary, taking into account the finding of this Impact Assessment as well as the outcomes of initiatives in the field of energy policy (Offshore renewable energy, Energy System Integration, Hydrogen strategies and Renovation wave). Correspondingly also different intensification levels of transport policies are analysed.

5.2.2.1 Role of ETS and ESR, scope of carbon pricing

In the context of climate legislation, a key issue is whether the current scope of the EU ETS and the effort sharing regulation should be retained, or the scope of both regulatory instruments should be changed. The Green Deal Communication confirms that the Commission will look into the possibility of including the building sector and road transport in emissions trading.

Covering of these sectors by an emissions trading system would provide for increased economic and more harmonised incentives to reduce emissions across these sectors in the EU, and depending on the stringency of the cap, increased certainty of delivery of the GHG emission reductions for those sectors. Inclusion in the current EU ETS can impact the sectors already included, notably due to potential carbon price developments, which in itself is also linked to the ambition and interaction with energy efficiency, renewable energy, transport and other policies

impacting these emissions. Finally, administrative feasibility and related costs are also of importance before making changes to the scope of the existing instruments.

To assess all this, a number of options are assessed that would include these sectors into the EU ETS or other emissions trading systems, possibly impacting the scope of the ESR that currently sets national targets for all GHG emissions^{70,71} outside of the EU ETS.

The scenarios presented in section 5.4 include such a stylised representation of expansion or not of carbon pricing and possible inclusion of new sectors in emission trading systems. Results of this scenario assessment are discussed in section 6.2 to 6.5. Section 6.7 then has a more detailed qualitative discussion of the benefits and challenges of options presented in this section while section 6.9 focuses on the associated potential impacts on free allocation and the risk of carbon leakage.

Option ETS_1: Current scope of ETS and ESR (baseline)

- Implement increased ambition (options GHG_2 and GHG_3) by adapting ETS and ESR in their current sectoral scopes. Serves also as “policy architecture” baseline to compare the subsequent options ETS_2 to ETS_4.
- The ESR and ETS remain largely separate systems without sectoral overlap.
- EU ETS coverage of buildings related emissions limited to emissions related to fossil fuelled district heating, electric heating and electricity use of heat pumps⁷², while the rest is covered by the ESR.
- EU ETS coverage of transport related emissions is limited to aviation and emissions related to electric vehicles and electrified rail, while fossil fuelled road transport and non-electrified rail are covered by the ESR⁷³.
- Continued limited interaction is possible between the sectors covered under the ETS and ESR⁷⁴.

Option ETS_2: Extension of current EU ETS to more sectors

- Inclusion of certain sectors presently regulated in the Effort Sharing Regulation in the EU ETS, where high quality Monitoring, Reporting and Verification of emissions (MRV) is relatively easy so responsibility for emissions can be attributed to private sector actors, where price incentives work more effectively and/or distributional challenges are lower or can be addressed effectively in the ETS design.
- The main variant assessed here is to extend the coverage of the EU ETS to buildings in full and to road transport, while several variants of sector coverage are also looked at, e.g. including only buildings, only transport or covering all energy CO₂ emissions⁷⁵.

⁷⁰ Excluding emissions and absorptions from the LULUCF sector.

⁷¹ Emissions from maritime transport are neither covered by the EU ETS nor the ESR with the exception of domestic navigation, which is part of the ESR.

⁷² ICF et al. (forthcoming) estimate that the current share covered by the EU ETS is around 30% of total buildings emissions related to heating.

⁷³ ICF et al. (forthcoming) estimate that the current share covered by the EU ETS is around 10% of total transport related emissions mainly through aviation, while emissions related to electric vehicles are still below 0.1%.

⁷⁴ A limited set of Member States is allowed to transfer ETS allowances they can auction for compliance with their ESR national target. This is presently limited to 100 million allowances over the whole period 2021-2030 for all MS combined. Of course this does not preclude changes to these limits even with constant scope. In addition, Member States have already currently the possibility to ask for an opt-in of additional sectors into the EU ETS.

When sectors are included in the ETS, it will need to be decided if these sectors would remain covered by the ESR or not.

Sub-option ETS_2.1: new ETS sectors not retained in ESR

In this sub-option, sectors included into the EU ETS are no longer retained in the ESR scope and thus the only architectural climate legislation that applies on these sectors is the EU ETS.

Sub-option ETS_2.2: new ETS sectors remain in ESR

In this sub-option, the sectors included in the ETS remain still in the ESR and thus next to the ETS also the ESR applies on them. The ETS carbon price would act as an additional EU mechanism to achieve national emission reduction targets under the ESR.

Option ETS_3: Separate EU-wide emissions trading system for new sectors

Introduction of a separate EU-wide emissions trading system, next to the existing EU ETS that covers the power sector, industry and aviation. This separate ETS would include notably energy related CO₂ emissions of current ESR sectors and would thus put a cap and resulting carbon price on these emissions.

Also here the scope of the separate ETS matters, with as the main variant assessed a separate EU ETS for buildings and road transport, while also looking at scope variants.

A separate ETS could be introduced in a similar way as was the case for the setting up of the ETS for aviation, with specific allowances differentiated from the general ETS allowances and possible flexibilities to be foreseen between the existing and the new ETS.

The sectors covered by the new ETS would be maintained in the scope of the ESR, as the main purpose is to provide an additional EU carbon pricing instrument to help Member States to achieve national emission reduction targets under the ESR and the necessary further emission reductions in these sectors.

Even with an integrated EU ETS (option ETS_2) as an ultimate aim, this option might be relevant as a temporary or transitional solution to test in the new separate emissions trading system how price incentives and the necessary monitoring and verification rules work in practice. It would also provide lessons how the European ETS interacts with national policies and what are ETS price impacts, while avoiding impacts on sectors covered by the current EU ETS.

Option ETS_4: Obligatory carbon price incentives through national systems

Same as option ETS_1, it keeps the current split of EU ETS – ESR scope, but adds an obligation on Member States to create a national trading mechanism that would establish a minimum effective carbon price on CO₂ emissions. They will thus not be included in the EU ETS system, but through a national system a carbon price incentive will be set to assist in achieving the national ESR target.

The main sectoral variant assessed here is adding the obligation for buildings and road transport. Again, the other variants have been implicitly assessed with the related sectoral impacts described under other options applying.

⁷⁵ For a list of the variants of sector coverage, see Table 26 “ETS scope extension and projected ambition levels in ETS and ESR for different sectoral coverages”.

The main variant in terms of a pricing tool is a trading system. However, other variants have also been assessed, as Member States could also introduce or extend other tools to establish an effective carbon price. This could be preferably by means of a national carbon tax⁷⁶. This option could also be implemented by setting minimum carbon content elements of excise duties in the revised EU Energy Taxation Directive.

Apart from these options on the ETS and ESR scope and interaction, the assessment also looks at the impact of the target ambition and scope change as discussed in the options above on the current approach to avoid the risk of carbon leakage, notably the availability of allowances for free allocation. The principal tool to allocate allowances in the EU ETS is auctioning. For sectors that can pass through carbon costs in their product prices this does not raise risks related to carbon leakage. The alternative allocation method, for sectors which would shoulder most if not all of the carbon cost, is free allocation. This tool reduces the risk of carbon leakage for sectors that are exposed to international competition and cannot pass through easily carbon costs in their product prices. The choice between the above options will impact the total cap of allowances and thus the amount of allowances available.

This assessment will not explicitly look at what other tools can be introduced against the risk of carbon leakage. This will be done in the context of the impact assessment under preparation that will look at a carbon border adjustment mechanism⁷⁷.

5.2.2.2 Renewable energy policy

This section presents options for intensifying⁷⁸ renewable policies, which could require the revision of RED II. Importantly, the legislative options are not described in detail in this Impact Assessment but presented in a stylised manner. The scenarios presented in section 5.4 (and in more detail in Annex 9.3.4) include such a stylised representation of strengthening of policies, with one option including no strengthening at all of renewable energy policies compared to the baseline and other options including a low, medium and high strengthening (in combination or not with extension of carbon pricing). Results of this scenario assessment are discussed in section 6.2 to 6.5 with a specific focus on the impacts on renewable energy demand and supply in section 6.2.1.3. Section 6.6 then has a more detailed qualitative discussion of the benefits and challenges of options presented in this section.

Option RES_1 (Baseline): No intensification or new policies fostering deployment of renewable energy

This option is based on the current shape of REDII. Apart from setting an EU's binding at least 32% renewable energy target in 2030, it also provides an updated policy framework to further deploy renewable energies across all sectors serving as a common rulebook for the design of support schemes to facilitate a predictable, cost effective, market-oriented and Europeanised approach to ensure renewable electricity development. It requires the Member States inter alia to put in place a legal and an enabling framework for renewable energy communities and renewable self-consumption and to remove unjustified barriers to long-term renewables Power Purchase

⁷⁶ It could be considered to allow the possibility to also comply with the obligation by a rule-based opt-in of those sectors into the EU ETS, which, as mentioned above, is in principle already possible.

⁷⁷ <https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12228-Carbon-Border-Adjustment-Mechanism>

⁷⁸ Intensification of policies can mean expansion of scope of an existing measure or its scaling up, acceleration of implementation, tightening of an existing requirement or the introduction of new requirement(s).

Agreements. The Directive also establishes a number of measures aimed at reducing administrative burdens such as maximum duration for the permitting procedure or simplified procedures for grid connections for small-scale renewable energy production. The forthcoming Offshore Renewable Energy strategy will also propose actions to address specific barriers for offshore wind and other offshore technologies.

Furthermore, RED II requires Member States to endeavour to implement an increased share of renewable energy in heating and cooling by an indicative 1.3 percentage point (p.p.) per year in the period of 2021-2030, with up to 40% potentially to be fulfilled by waste heat and cold⁷⁹. District heating and cooling must participate in mainstreaming renewable energy in the heating and cooling sector⁸⁰. Buildings must include a minimum level of renewable energy. Availability of local renewable energy and waste heat sources should be taken into account in the urban and infrastructure planning.

RED II obliges Member States to set an obligation on fuel suppliers to achieve a share of at least 14% renewable energy in the transport sector in 2030⁸¹, including at least 3.5% of advanced biofuels and biogases⁸². The Directive focuses on the promotion of innovative fuels such as advanced biofuels and renewable fuels of non-biological origin (RFNBOs)⁸³. The contribution of biofuels produced from food and feed crop is limited based on their share in transport energy consumption in 2020⁸⁴. The obligation can be expressed in terms of minimum shares of renewable energy, volume of renewable fuels or as a requirement to reduce the greenhouse gas emission intensity of fuels providing the targets are met.

The EU level actions on renewable energy would therefore focus on the implementation of the existing 2030 framework, also by making use of the tools foreseen in the Governance Regulation. In addition, the greenhouse gas emissions intensity target for fuels and the fuels specifications set by the Fuel Quality Directive⁸⁵ also contribute to mainstream renewable fuels in transport.

Further deployment of renewable energy in all sectors requires a more integrated approach and a suitable internal market framework. More renewable electricity can be pulled by electrification of the demand and deployment of renewable and low-carbon fuels, notably clean hydrogen produced with renewable electricity. RFNBOs can play a bigger role in transport and could in the long term be also promoted in heating & cooling sector.

The EU strategies on Energy System Integration and on Hydrogen look into efficient integration of decarbonised supply of electricity, mostly coming from renewables, together with renewable and low-carbon fuel production with transport, heating and cooling and industrial processes will be a significant enabler for the uptake of these energy carriers.

Option RES_2: Low intensification of RES policies

⁷⁹ In Member States where waste heat or cold is not used, the yearly increase to endeavour to achieve is 1.1 pp.

⁸⁰ This could be either by endeavouring to implement an indicative annual average increase in renewables and/or waste heat of 1 p.p. or by giving third party access to suppliers of renewable energy and waste heat.

⁸¹ While renewable fuels consumed in all transport modes can contribute towards achieving these targets, the target itself is set as a share of fuels consumed mostly in road and rails transport.

⁸² Produced from feedstocks included in Annex IX Part A of REDII.

⁸³ For compliance purposes with the abovementioned targets, multipliers apply to the share of biofuels and biogas and renewable electricity.

⁸⁴ Their share cannot exceed 7% of transport energy consumption. High Indirect Land Use Change (ILUC) risk biofuels are gradually phased out.

⁸⁵ Directive [2009/30/EC](#)

Building on Option RES_1, the EU renewable energy target for 2030 is adjusted with the sub-targets and measures for heating and cooling and transport (notably for maritime and aviation sectors reflecting ReFuelEU aviation and FuelEU maritime initiatives) slightly modified, accordingly. This could also be supported by non-regulatory alternative policy instruments that could encompass training, information campaigns, project financing etc. that would complement the complete and rigorous transposition of RED II by Member States.

Option RES_3: Moderate intensification of RES policies

This option builds on Option RES_2 and, in addition, implements the Renewable Offshore Energy Strategy that creates better framework conditions for the uptake of, especially, offshore wind and provides guidelines, capacity building schemes to implement renewable energy communities financed by the EU and self-consumption models enabling higher consumer uptake and faster development of decentralised renewable energy technologies. Cross-sectoral renewable energy policies, covering streamlined administrative procedures for renewable projects, provisions on installers of renewable energy technologies, deployment of corporate power purchase agreements (PPAs) including in heating and cooling are all strengthened. It introduces measures enhancing coordinated planning such as green criteria and labels, including for cross-border schemes, also located off-shore, which would enable further renewable energy deployment reducing lead times and lowering costs.⁸⁶

Building on Option RES_2 in heating and cooling, option RES_3 increases the heating and cooling target, including for district heating and cooling. This could be supported by strengthening of the regulatory framework to mainstream renewable based solutions for heating and cooling in all sectors and through requirements to accelerate the roll out of smart, renewable energy-based district heating and cooling networks, as well of the development of alternatives to fossil fuels for energy and industrial uses. Co-operation between electricity distribution network and district heating and cooling operators is intensified to better reflect demand response and flexibility from storage in energy network investment.

Furthermore, risk mitigation instruments and flanking measures are introduced to reduce the perceived risks and fragmented nature of renewable heating and cooling solutions.

In the transport sector, an obligation is placed on fuel suppliers, with increased ambition for deployment and further mainstreaming of renewable and low carbon fuels, including advanced biofuels and biogases as well as RFNBOs in transport in order to speed up their commercial deployment. Increased promotion of the use of renewable and low carbon fuels, including advanced biofuels and biogases as well as RFNBOs in the aviation and maritime sectors reflecting REFUEL aviation and FUEL maritime initiatives is also introduced.

Option RES_4: High intensification of RES policies

This option builds on Option RES_3 but with higher intensification of RES stylised policies to deliver the respective emission targets.

⁸⁶ The rules on security of supply are assumed to be met in the scenarios, including adequacy rules, reinforcement of critical energy infrastructure protection and cybersecurity as well as the resilience of supply chains for clean energy technologies.

The RES heating and cooling target includes specific renewable energy mandates for buildings, district heating and cooling and industry. It also includes strengthening of the policies and measures to deliver the target that are outlined in option RES_3.

For transport, further mainstreaming of renewable and low carbon fuels, including advanced biofuels and biogases as well as RFNBOs, in all transport sectors are intensified, covering also the aviation and maritime sectors (reflecting REFUEL aviation and FUEL maritime initiatives).

5.2.2.3 Energy efficiency policy

This section presents options for intensifying⁸⁷ energy efficiency policies⁸⁸, which could require the revision of EED, EPBD and product legislation as well as scaling up financial instruments and other enabling measures⁸⁹. Importantly, the legislative options are not described in detail in this Impact Assessment but presented in a stylised manner, not pre-judging detailed assessments to be delivered in dedicated impact assessments⁹⁰. The scenarios presented in section 5.4 (and in more detail in Annex 9.3.4) include such a stylised representation of strengthening of policies, with one option including no strengthening at all of energy efficiency policies compared to the baseline and other options including a low, medium and high strengthening (in combination or not with extension of carbon pricing). Results of this scenario assessment are discussed in section 6.2 to 6.5 with a specific focus on the impacts in buildings and industry in annex 9.4.2.5 and annex 9.4.2.7. Section 6.6 then has a more detailed qualitative discussion of the benefits and challenges of options presented in this section.

Option EE_1 (Baseline): No intensification of energy efficiency policies

This option does not foresee intensification of energy efficiency policies by 2030, and therefore the current framework would not be revised⁹¹ to support higher climate ambition – neither in terms of regulatory nor financial/enabling measures. The EU level actions on energy efficiency would therefore focus on the implementation of the existing 2030 framework, also by making use of the tools foreseen in the Governance Regulation.

Option EE_2: Low intensification of EE policies

Building on Option EE_1, the EU energy efficiency target for 2030 is adjusted with low intensification of policy measures. This could be achieved by non-regulatory alternative policy instruments notably in terms of financing, additional guidance and reinforced the application of

⁸⁷ Intensification of policies can mean expansion of scope of an existing measure or its scaling up, acceleration of implementation, tightening of an existing requirement or the introduction of new requirement(s). In some other cases, the intensification of energy efficiency policy can be its desired outcome, in terms of expected energy savings or reduction in energy consumption, without specifying in which way this is achieved.

⁸⁸ The Energy Efficiency Directive (Directive 2012/27/EU) (EED) is the cornerstone of the broader EU energy efficiency policy framework, which brings together other key instruments such as the Energy Performance of Buildings Directive (2010/31/EU) (EPBD), the Energy Labelling Regulation ((EU) 2017/1369) and Ecodesign Directive (2009/125/EC) with multiple interlinkages and synergies among these instruments.

⁸⁹ The policy options of either cross-cutting or sectoral nature are presented following the policy architecture described in section 5.2.1.1 that escalates energy efficiency overall ambition (no additional measures/low/medium/high) – in line with increased GHG target and also in interplay with carbon pricing measures.

⁹⁰ Such analysis would build on an evaluation study and on other targeted analysis which are not yet concluded at the time of completing this impact assessment.

⁹¹ A targeted revision of the EED could be needed for a different reason – in order to close the ambition gap in the final NECPs.

the “energy efficiency first” principle, that would lead to better implementation of the EED by Member States.

Option EE_3: Moderate intensification of energy efficiency policies

The moderate intensification of policy measures, which could be undertaken at EU level to ensure a moderate increase of the overall energy efficiency ambition, implies the review of some elements of the EE legislative framework together with the scaling up of the financial and other enabling measures supporting them.

Buildings

The acceleration of the renovation of existing buildings, especially the worst performing segment of the building stock, offer a high potential for energy savings and is at the core of the policy options for increased energy efficiency ambition. Through a targeted reinforcement of the policy measures in the EPBD, EED and in product legislation, accompanied by scaling up of financial and other enabling measures, the number of renovations could be significantly increased.

The main provisions for buildings under the EPBD which could be strengthened under this option covers the Energy Performance Certificates, uptake of building automation and control systems, cost-optimal requirements and targets for Near Zero Energy Buildings. Moreover, the Energy Efficiency Directive has in place a set of measures e.g. on renovation of public buildings, procurement, heating and cooling, energy audits, financing which have the potential to be extended and reinforced to deliver higher savings and further address barriers preventing energy efficiency actions to a larger scale. Finally, the level of ambition and the scope of the provisions on various products used in buildings covered by the Energy Labelling Regulation and Ecodesign Directive could also be increased.

The policy measures to be reinforced are in this option accompanied by scaling up of financial and other enabling measures in order to address perceived financial risk factor for investors – a barrier in buildings renovations.

A strengthened set of measures would lead to an increase of the current renovation rates and depths of renovations achieved and would contribute to building stock modernisation, also in the light of technological developments (integrating renewable solutions, smart solutions, supporting electro mobility, high performance energy efficiency measures, etc.).

Industry

In order to further reduce emissions from industry in line with the higher climate target for 2030, major changes need to be made in the way industry consumes energy and produces its products notably via increased material and energy efficiency, greater material recirculation, new production processes and carbon capture technologies⁹².

⁹² A potential exists both for cost-effective and quickly repayable energy efficiency measures, and energy efficiency measures as component of more radical, deep decarbonisation options. A recent study showed that the energy savings potential driven by existing and well known energy savings opportunities is considered to be higher than 20% of current energy consumption and the economic saving potential is very close to its technical saving potential, which speaks in favour for a high overall cost-effectiveness. Over 70% of energy saving potential for the industrial sector could be attributed to improvements in process heating, of which around 33% related to improvement of process heating control system. On this, over 15% of the energy saving potential could be attributed to improvement of motor systems, these include application of premium efficiency motors, demand-controlled ventilation, optimisation of

This option explores intensification of energy efficiency policies in industry through reinforcement of several EED measures to address the existing barriers still preventing cost-effective energy savings solutions. These could refer mainly to the audit requirements and follow-up of their outcomes by the audited companies as well as waste heat reuse. In addition, eco-design and labelling requirements for products used in industry could also be strengthened.

These policy measures are accompanied by scaling up of financial and other enabling measures.

ICT

On the one hand, digitalisation has a potential role in optimising and reducing energy consumption. On the other hand, there is also a growing demand for energy (and in turn growing emissions) from the ICT sector, in particular data centres. Considering that the ICT sector has not been specifically addressed in the energy efficiency policy framework from the system functioning perspective, this option explores in a highly stylised manner potential new actions in this area which could be implemented through several EED measures strengthened and extended to better cover ICT products and data centres.

Option EE_4: High intensification of energy efficiency policies

This option builds on Option EE_3 and further intensifies policy measures at EU level to ensure a further increase of the overall energy efficiency ambition. It implies additional elements of the EE legislative framework together with the scaling up of the financial and other enabling measures supporting them.

The additional measures are:

Buildings

Following the same logic explained in Option EE_3, the policy options outlined would go further to achieve higher savings in the residential and non-residential sectors through further acceleration of the renovation, i.e. by at least doubling or tripling of the total renovated area as compared to 2020 and by increasing the renovation depth (aiming at increased energy savings per renovation and incentivising the shift from light/medium renovations towards deep).

These more ambitious policy measures are accompanied by scaling up of financial and other enabling measures.

Industry

In this option, the same policy measures as in Option EE_3 are considered but developed to a higher degree of intensity to achieve higher energy savings.

ICT

ventilation system, control system optimization and premium efficiency speed drives. *ICF (2020), Technical assistance services to assess the energy savings potentials at national and European level.*

As regards the ICT sector, the same measures as in Option EE_3 are applied.

5.2.2.4 Transport policy

For the transport system, multiple policies can reduce GHG emissions.

Policies that directly impact emissions relate to CO₂ emission standards for vehicles as well as policies that impact the carbon intensity of fuels (as already discussed in the section on renewable policies). Both are supported by the roll-out of recharging and refuelling infrastructure.

The existing CO₂ emissions standards⁹³, set binding progressively stricter targets from 2020, 2025 and 2030 for car, van and truck manufacturers to reduce emissions and thus fuel consumption. But to achieve even higher GHG ambition, further increases in ambition in relation to this policy need to be assessed.

Other policies that indirectly impact also GHG emissions of transport are diverse and include wide span of possible actions. They include policies that impact modal shift, development of related infrastructure, traffic management systems, pricing systems addressing other externalities and promote digitalisation of the transport system.

As for renewable energy and energy efficiency policies discussed above, the current analysis does not pre-empt dedicated impact assessments. Most of the policies can all be intensified step-wise (notably CO₂ standards for vehicles) and three options can be identified: no strengthening at all of transport policies compared to the baseline and other options including a low, medium and high strengthening (in combination or not with extension of carbon pricing). See section 5.4 and Annex 9.3.4 for more details.

Option TRA_1 (Baseline): No intensification of transport policies

This option is based on current shape of transport legislation and has thus a number of policy measures that drive: (i) the uptake of zero- and low-emission vehicles and the roll-out of recharging/refuelling infrastructure; (ii) the uptake of sustainable alternative fuels and (iii) improvements in transport system efficiency - by making the most of digital technologies and smart pricing and further encouraging multi-modal integration and shifts towards more sustainable transport modes. Specific measures are also applied for aviation and maritime sectors. See annex 9.3.3.1 for more details.

Option TRA_2: Low intensification of transport policies

In this option, a low intensification of policy measures is considered that drives improvements in the transport system efficiency and support a shift towards more sustainable transport modes. Such policies would be combined with policies that impact the carbon intensity of fuels in

⁹³ The existing legislation sets for newly registered passengers cars, an EU fleet-wide average emission target of 95 gCO₂/km from 2021, phased in from 2020. For newly registered vans, the EU fleet-wide average emission target is 147 gCO₂/km from 2020 onward. Stricter EU fleet-wide CO₂ emission targets, start to apply from 2025 and from 2030. In particular emissions will have to reduce by 15% from 2025 for both cars and vans, and by 37.5% and 31% for cars and vans respectively from 2030, as compared to 2021. From 2025 on, also trucks manufacturers will have to meet CO₂ emission targets. In particular, the EU fleet-wide average CO₂ emissions of newly registered trucks will have to reduce by 15% by 2025 and 30% by 2030, compared to the average emissions in the reference period (1 July 2019–30 June 2020). For cars, vans and trucks, specific incentive systems are also set to incentivise the uptake of zero and low-emission vehicles.

maritime and aviation sectors (as already discussed in the section 5.2.2.2 on renewable policies) as well as increased stringency of CO₂ standards for vehicles.

Option TRA_3: Moderate intensification of transport policies

In this option, a moderate intensification of policy measures is considered that drives improvements in the transport system efficiency and support a shift towards more sustainable transport modes. Such policies would be combined with moderate intensification of policies that impact the carbon intensity of fuels across all transport modes and in maritime and aviation sectors specifically (as already discussed in the section 5.2.2.2 on renewable policies) as well as increased (compared to TRA_2) stringency of CO₂ standards for vehicles.

Option TRA_4: High intensification of transport policies

In this option, further (to Option TRA.3) intensification of policy measures is considered that drives further improvements in the transport system efficiency and support more a shift towards more sustainable transport modes. Such policies would be combined with high intensification of policies that impact the carbon intensity of fuels across all transport modes and in maritime and aviation sectors specifically (as already discussed in the section 5.2.2.2 on renewable policies) as well as increased (compared to TRA_3) stringency of CO₂ standards for vehicles.

5.2.2.5 Policy options to increase net removals in the LULUCF sector

Land Use, Land Use Change and Forestry presently absorbs more CO₂, by storing it in biomass or in soil carbon, than it releases to the atmosphere. Actions can be taken that would increase the EU sink. These can be diverse and include increased afforestation, reforestation of damaged forests, elimination of deforestation, improved agricultural land management practices, impacts of changed consumer behaviour and related dietary options, substitution of fossil materials with (in particular) wood products, the careful identification of efficient bioenergy pathways and restoration and stabilisation of key biodiverse habitats, such as legacy peatlands and wetlands. This last action – which would align strongly with the Biodiversity strategy⁹⁴ – could be underpinned by designing zoning of protected areas based upon high carbon stocks or sink capacity, thus ensuring strong synergies between climate mitigation and biodiversity objectives.

This section describes specific options related to climate policy architecture that could incentivise the undertaking of such action and thus result in an expansion of the sink compared to baseline.

The scenarios presented in section 5.4 allow to assess the relation of the LULUCF sink with the decarbonisation of the energy system, notably related to the impact from increased bio-energy demand as well as the potential impact of some of the above mentioned actions to enhance the sink. Section 6.2.3 assesses the potential impacts on the size of the LULUCF sink. Section 6.10 will then have a more qualitative discussion on the benefits and challenges related to the climate architecture policy options presented in this section to enhance the sink by 2030 and how it relates to overall climate ambition.

Option LULUCF_1: Baseline continued

The current policy framework is designed so that Member States can earn additional LULUCF credits if they do not backslide compared to the sink under ‘current practices’. This sink under ‘current practices’ is established using different computation rules for different land accounting

⁹⁴ COM(2020) 380 final

categories (afforested land, managed cropland, etc.⁹⁵). For most land categories the accounting rules look at actual performance in a historic base year period 2005-2009. For forest management instead, the largest sink category, projections are made that estimate how the sink would evolve assuming the continuation of forest management practices as documented in the period from 2000 to 2009 (referred to as Forest Reference Levels). The entire LULUCF sector account is aggregated per land category to determine if a Member State enhances the sink compared to ‘current practices’ or instead deteriorates it and increases emissions compared to this accounted reference levels.

If the aggregated account is an emission (i.e. an accounted debit), flexibilities permit the Member State to compensate this using an unlimited quantity of ESR allowances, or alternatively via LULUCF ‘credits’ traded with other Member States within the LULUCF sector.

By contrast, a Member State that enhances accounted removals may use this LULUCF ‘credit’ to compensate a lack of allowances for the achievement of its own ESR target, up to fixed limits per Member State and limited to 262 Mt overall in the period 2021-2030 for EU27. This flexibility towards the ESR is not only limited in quantity per Member States, it cannot be traded to other Member States. This limitation was set to preserve the ambition in the ESR itself and as such this flexibility is thus rather limited. Compensation levels are designed per Member State to acknowledge the more limited mitigation potential of the agriculture sector and give access to more flexibility from the LULUCF sector to Member States with relative large agriculture non-CO₂ emissions in the ESR.

Option LULUCF_2: Incentivising additional action in the LULUCF sector

This option assesses how climate policy architecture can be changed to incentivise more than in baseline the preservation and enhancement of the EU sink. It will also assess the “fit for purpose” of the policy framework for the period also beyond 2030 with a view on climate neutrality by 2050.

Three sub-options are assessed of such policy instruments:

- **Sub-option LULUCF_2.1: Increase the flexibility of LULUCF credits towards the ESR and/or ETS**

This sub-option increases flexibility – currently limited to 262 Mt for the period 2021-2030 – towards the remaining ESR sectors. Potentially also flexibility to the ETS could be considered. Increased ambition and thus demand for reductions in the ESR and possibly the ETS becomes a key driver for additional actions in the LULUCF sector in this sub-option. This would leave for the rest the LULUCF regulation unchanged in terms how LULUCF credits or debits are generated.

With regard to the flexibility towards the ESR and the regulatory framework in this sub-option, Member States would be the actors in terms of generating LULUCF credits and buying/selling LULUCF credits. This means every Member States would have the possibility to design their own incentive scheme(s) to ensure that the carbon price signal is transmitted to individual actors (farmers and foresters).

Several ways are available to provide an incentive to farmers and foresters to ensure responsible land and forest management. This includes pricing mechanisms already existing in the Common Agricultural Policy today that can be developed through Member State Strategic Plans, eco-

⁹⁵ See Art 2 of Regulation (EC) 2018/841 for a full description of land accounting categories

schemes and project funding under the Rural Development programme. Nevertheless, through this increased flexibility Member States may decide to reward from their own budgets or through CAP farmers and foresters for the carbon capture and environmental services, and thereby enable transfers from the rest of the economy to the farming/forestry sector.

- **Sub-option LULUCF_2.2: Strengthening of LULUCF regulation – moving towards a more stringent contribution from the sector**

This sub-option would review the LULUCF regulation in a manner that makes it more stringent before credits can be generated and transferred to the ESR or other Member States. Contrary to the previous sub-option, the Member State would have to take additional efforts first before it could transfer LULUCF credits to other parts of the economy covered by ESR or ETS targets.

This sub-option would in practice require a setting of Member State-specific targets beyond the current accounting rules per land category, which will require technical analysis of cost-equivalent as well as environmentally equivalent potential per Member State.

Approaches could be to require an automatic cancelling (or discounting) of an initial amount of LULUCF credits before LULUCF credits can be generated that can be transferred to the ESR or other Member States. Another approach could be change to change some of the accounting rules that apply for individual land accounting categories making the LULUCF regulation de facto more stringent. This can also impact ESR ambition if LULUCF accounting would result more frequent in debits which need to be compensated.

Forestry accounting in particular would be a specific case to consider, including the revision of the Regulation's Art 8 concerning the setting of the Forest Reference Level – where a simpler, more direct approach of historical benchmarking based on net-net accounting could provide considerable quantitative effects.

- **Sub-option LULUCF_2.3: Merging Non-CO₂ emissions from agriculture with LULUCF emissions creating an AFOLU sector with a separate target**

This sub-option will assess the full range of flexibility within the agriculture, forestry and land use sectors. If the ESR would be considerably changed – for example buildings and transport moved to the scope of the ETS (see section 5.2.2.1), the largest remaining emissions in the ESR would be from agriculture, notably the non-CO₂ emissions. The agriculture sector would in practice be left adjacent to the LULUCF sector. A policy architecture that combines more explicitly both sectors into one legal instrument may ease designing efficient and effective policies in these sectors and better align them with EU agricultural policy instruments.

Looking at the scenarios in the analysis supporting the long-term strategy, EU Agriculture, Forestry and Land Use (AFOLU) emissions would have to get to balance at the latest by 2035 at the EU level but with differences between Member States. Therefore, this sub-option would in practice require a similar setting of Member State-specific targets (as in sub-option LULUCF_2.2). Furthermore, the option should consider if this “AFOLU” sector could benefit from flexibility to and from the other remaining ESR and/or ETS sectors.

5.2.2.6 Role of non-CO₂ emissions reductions

The achievement of a certain climate ambition, will not only depend on actions related to reducing CO₂ emissions from the energy system and increasing the net sink of the LULUCF sector but will also depend on what reductions can be achieved in non-CO₂ emissions reductions.

Main emitting sectors are agriculture (notably CH₄ emissions from enteric fermentation and N₂O emissions linked to fertiliser and manure application), the energy system (linked to fugitive CH₄

emissions *of* the natural gas as well as emissions linked to the combustion of fuels), the waste sector (CH₄ emissions stemming from uncaptured emissions from anaerobic digestion of waste stream) and industrial processes and manufactured products that require or contain F-gases.

Depending on the level set for energy ambition, more or less non-CO₂ emission reduction ambition will be required in to achieve a certain absolute climate target. These options will explore how these interact.

Option NCO2_1: No additional contribution to GHG reductions

In this option no additional measures are undertaken to reduce non-CO₂ emissions beyond what is presently foreseen in legislation. Key drivers here are EU legislation in the field of waste policy and F-gases. Regarding agriculture emissions this option does not incorporate any specific policies that might be undertaken under the future Member States' CAP strategic plans or other new policy initiatives under the European Green Deal. For energy emissions similarly no additional policies are introduced that would specifically target fugitive emissions in the sector.

Option NCO2_2: Moderate additional contribution to GHG reductions

In this option, a moderate intensification of action to reduce non-CO₂ emissions is considered that relies on policies that from a bottom up perspective are win-win policies and can be deliver at marginal costs below €1/tCO₂-eq reduced⁹⁶. Lack of information (for instance regarding the benefits of certain breeding strategies) and split incentives (for instance in the ownership of pipelines and gas transported) may still require significant policy intervention to achieve these relative low cost emission reduction potentials.

Option NCO2_3: High contribution non-CO₂ to overall GHG reductions

In this option, a higher intensification of action is considered that relies on policies that from a bottom up perspective⁹⁷ require intermediate carbon prices similar to options that achieve energy emission reductions through regulation or combination of regulation and carbon pricing.

Option NCO2_4: Very high contribution non-CO₂ to overall GHG reductions

In this option, a higher intensification of action is considered that relies on policies that from a bottom up perspective⁹⁸ require high carbon prices similar to options that achieve energy emission reductions only through extension of carbon pricing tools and no enhancement of other regulatory tools.

5.2.2.7 Summary of policy options related to policy framework

Table 2 gives a summary of the various policy options assessed in this Impact Assessment, in relation with general and specific objectives related to the policy framework described in section 4.

⁹⁶ Applying the marginal abatement curves of the GAINS model.

⁹⁷ Applying the marginal abatement curves of the GAINS model.

⁹⁸ Applying the marginal abatement curves of the GAINS model.

Table 2: Summary of policy options related to the policy framework

Policy framework	2.1 Role ETS and ESR, scope of carbon pricing	ETS_1	No change
		ETS_2.1	ETS includes road transport and buildings, no ESR application
		ETS_2.2	ETS includes road transport and buildings, possible application of ESR
		ETS_3	EU trading system for current non-ETS sectors
		ETS_4	MS carbon trading scheme for buildings and road transport
	2.2 Renewable energy	RES_1	No ambition increase
		RES_2	Low ambition increase
		RES_3	Medium ambition increase
		RES_4	High ambition increase
	2.3 Energy efficiency	EE_1	No ambition increase
		EE_2	Low ambition increase
		EE_3	Medium ambition increase
		EE_4	High ambition increase
	2.4 Transport	TRA_1	No ambition increase
		TRA_2	Low ambition increase
		TRA_3	Medium ambition increase
		TRA_4	High ambition increase
	2.5 LULUCF	LULUCF_1	Current policy
		LULUCF_2	New policy options
	2.6 Contribution of Non-CO2 emissions	NCO2_1	No additional contribution
NCO2_2		Moderate additional contribution	
NCO2_3		High additional contribution	
NCO2_3		Very high additional contribution	

5.2.3 Policy interactions

The policy options on ambition levels/targets, and the policy measures to deliver them described in the sections above, interact in many ways and should not be seen in separation, but rather in combination. The experience to date in the implementation of current energy and climate policies provides examples for such interactions. These interactions are likely to intensify when the scope or intensity of climate and energy policies changes as described in the policy options above.

For instance, energy saving policies are currently primarily focused on non-renewable energy. In the future, policies fostering high energy efficiency would help to avoid bottlenecks and allow the share of renewable energy to grow in total energy consumption without a need to increase the renewable energy production capacities excessively.

Policies fostering the replacement of highly-emitting fossil fuels in power generation by variable renewable energy for instance leads not only to reduction of GHG emissions but also lowers primary energy consumption⁹⁹. Policies targeting the electrification of end-use sectors (for example fostering the deployment of heat pumps and electric vehicles) helps reduce final energy consumption and creates an additional pull for electricity supply that is increasingly renewables-based. Electrification is also more efficient compared to the use of biomass-based fuels and the primary energy needed to produce hydrogen or e-fuels.

Transport policies targeting modal shift, traffic management systems (including through digitalisation) and pricing systems addressing carbon and other externalities have all a positive impact on efficiency of transport system and contribute to overall energy efficiency performance and lower GHG emissions. In addition, transport policies that focus on infrastructure development are pre-condition for the roll-out of alternative fuels (notably renewables) and the roll out of zero emission vehicles as required under increasingly stringent CO₂ standards vehicle standards.

⁹⁹ Due to the way different fuels are considered in statistical calculations

While most of the transport, energy and climate policies have positive interactions, interaction between deployment of biofuels and land use has been a source of concern as increasing use of biomass inputs is in competition with the use of land for other purposes and will need to be managed carefully.

The nearly zero-energy building requirements promote high energy performance buildings with very low energy consumption supplied to a large extent from solutions based on renewable energy. Quicker deployment of such buildings may also support the increase in the number of charging points for electro-mobility.

Further policy interactions would be observed in the future if emissions trading and/or a carbon price component of energy taxation to cover also buildings and road transport sectors were introduced. This would create an overlap with some of the energy efficiency and renewable energy policy measures at EU and national level¹⁰⁰. Considering existing market failures and low price elasticities in these sectors, carbon pricing, depending on its design and stringency, would need to work in concert with EE and RES policies and vice versa, which would *inter alia* help mitigate the effects on energy prices faced by the final consumers.

It is therefore important to ensure coherence between the different policies in the future policy framework. The interactions stemming from the policy options, both positive and negative, can be fully assessed only when complete policy design is put forward (obligated entities, implementation, monitoring, verification, mandatory versus voluntary nature, etc.). They should be addressed through the policy design of each specific measure as well as implementation and monitoring when legislation is proposed (e.g. within coherent policy packages).

This Impact Assessment prepares for analysis of such future interactions by looking at combinations of climate and energy policy options grouped in the scenarios described in section 5.4 considering that, in most sectors, actual GHG reductions have and will occur through a combination of carbon price incentives and/or sectoral policies, notably including EE and RES policies.

5.3 Options not addressed in the Impact Assessment

Possible scenarios representing 2030 EU GHG emissions reduction target below 50% were discarded at an early stage as they do not fulfil the political mandate contained in the President's Guidelines and the European Green Deal. Furthermore, such options would not represent a sufficient ambition increase compared to Existing Targets Baseline.

In line with the political mandate, scenarios assessed look at the impact of achieving 50 to 55% GHG reduction including the role of the LULUCF sink and international aviation and navigation emissions.

Some stakeholders have asked for a higher target – up to 65% or more GHG reduction by 2030 but scenarios with an EU GHG reductions target of over 55% were not assessed in this IA. The objective of this impact assessment is to assess an increase of the 2030 GHG target to be achieved in a *responsible* manner, following the President's Guidelines and the European Green Deal, which will require mitigating all negative social and economic impacts associated with the transition. Stepping up ambition up to 50% to 55% significantly increases the speed of the

¹⁰⁰ Many energy efficiency instruments exist at national level, from regulatory to fiscal, financial and market-based instruments.

transition in the short term, while ensuring there is no back-loading of EU action to achieve climate neutrality. A target of over 55% would front-load the efforts strongly. At the same time, the challenges associated with an even faster transition would increase.

Furthermore an assessment of global mitigation scenario confirms that a pathway in the range of 50% to 55% by 2030 fits a representative set of modelling exercises looking at achievable and responsible global emission pathways (see also annex 9.10.6). Finally, the increase of the target should reflect the rigidities, long lead times and the general inertia of the energy system and heavy industry, where infrastructure is characterised by long lifetimes and thus change can only be gradual in certain sectors. For the above reasons, options higher than 55% for 2030 have been discarded.

No scenarios without increasing EE and RES ambition - one of them or both - were analysed as they would depart from current legislation and miss on synergies that are crucial for a cost-effective achievement of 2030 GHG target. The experience with policies to date proves that the targets for GHG emissions reduction, RES and EE ambition reinforce each other. All scenarios therefore assume GHG/EE/RES targets/levels of ambition.

As indicated in the section 5.2.1, theoretically many combinations of GHG targets with EE and RES levels of ambition exist. In practice, these combinations need to be coherent in order to be effective. This Impact Assessment also takes into account Member State choices. Therefore it did not analyse a scenario with a very high RES ambition compatible with a fully RES based energy mix in the foreseeable future, as this option would not reflect the current reality of energy mix options put forward by some Member States.

In a similar manner there is, theoretically, many possible policy combinations to achieve the overall levels of GHG targets and EE and RES levels of ambition. Scenarios in this Impact Assessment take into account the existing EU and national policies, including regarding their energy mix, and aim for future policy mix that is coherent to implement. This is why no scenarios were developed that would put an exaggerated burden of the transition on a specific sector or technology or have an asymmetric distribution of effort or would be inconsistent with the progress achieved so far.

5.4 From policy options to policy scenarios

The policy options presented in Section 5.2 cover a very wide spectrum of issues that needs to be assessed. These options are interdependent or have complex interactions. Coherent combinations of policy options were translated into policy scenarios so that a quantitative assessment can be performed using sectoral models. Such assessment can show in detail the type and distribution of changes that will need to occur in our energy, industrial, waste and land based sectors. Furthermore, a macro-economic assessment is made to assess the economy wide implications. All scenarios have valuable insights for the public debate and represent options for policy-makers.

The PRIMES-GAINS-GLOBIOM modelling toolset covers in detail all sectors of the EU economy and their related GHG emissions and CO₂ absorptions. Energy and industrial CO₂ emissions are assessed with the PRIMES model, including the PRIMES-TREMOVE model for more detail on the transport sector. Non-CO₂ emissions (CH₄, N₂O and F-gases) of the waste, energy, agriculture and industry sectors are assessed with the GAINS model. Land use emissions and removals are assessed with the GLOBIOM model. See annex 9.3.1 for more detailed information on this modelling suite. For a discussion on the update made of the modelling assumptions, which was being done in the context of an ongoing periodic update of the EU

Reference Scenario on energy, transport and GHG emissions, see annex 9.3.2. This update process is still ongoing and Member State detail has not been fully revised yet. Therefore the modelling used for this assessment focusses on EU-wide modelling results.

This detailed and coherent EU wide representation of all GHG emission sources allows to show complex interactions of combinations of policy tools. A key issue for this Impact Assessment was to identify a sufficient but manageable number of scenarios, which explore different combinations of policy options as presented in section 5.2. Among these policy options, the following questions were explored in modelling:

- the extent to which carbon pricing is extended to sectors that are currently not covered by the EU Emissions Trading System;
- the role of the energy efficiency and renewables policies;
- the role of other policies (notably in the field of transport).
- the scope of the GHG target, notably related to the inclusion of international navigation and aviation emissions.
- the role of the land use sector in contributing to the GHG ambition

The scenarios were constructed around a set of specific policies that either focus on carbon pricing (e.g. through inclusion of new sectors in the ETS) or focus on regulatory measures (e.g. CO₂ emission standards for vehicles, blending mandates for low carbon or renewable fuels in transport, renovation requirements, support for electrification of transport and heating, etc.) or combine the two. Stylised modelling applying these general policy incentives then allows to discover where there is emissions reduction potential and how policies interact. This approach allows to compare the different sets of policy options, the resulting synergies and trade-offs in a coherent framework. On the other hand, there are inherent limitations in such modelling exercise, notably in terms of detailed representation of specific policies, differentiated impacts on economic actors as well as specific challenges that will be encountered in the implementation of these policies.

Figure 3 gives a schematic overview of the scenarios developed for this IA which are assessed with the PRIMES-GAINS-GLOBIOM modelling suites. Further detail can be found in annex 9.3.4.

The following scenarios were developed.

- **BSL**, achieving the existing 2030 GHG, RES and EE EU targets;
- **REG**, a regulatory-based measures scenario that achieves around 55% GHG reductions. It assumes high increase of the ambition of energy efficiency, renewables and transport policies, while keeping the EU ETS scope unchanged. This scenario thus does not expand carbon pricing and relies mostly on other policies;
- **CPRICE**, a carbon-pricing based scenario that achieves around 55% GHG reductions. It assumes strengthening and further expanding of carbon pricing, be it via EU ETS or other carbon pricing instruments, to the transport and buildings sectors, combined with low intensification of transport policies while not intensifying energy efficiency, renewables policies;
- **MIX**, following a combined approach of REG and CPRICE, which achieves around 55% GHG reductions, both expanding carbon pricing and moderately increasing the ambition of policies, but the latter to a lesser extent than in REG;
- **MIX-50**, an increased ambition scenario achieving at least 50% GHG reductions, similar to MIX in that it combines both expanding carbon pricing and increasing the ambition of energy and transport policies but to a more limited extent than in MIX;

- **ALLBNK**, the most ambitious scenario in GHG emissions reduction, based on MIX and further intensifying fuel mandates for aviation and maritime sectors in a response to the extended scope of GHG reductions covering all aviation and navigation.

To complete the assessment a limited number of variants on the above scenarios were introduced:

- **EU-NECP variant of BSL**, reflecting in a stylised manner and to the extent possible the aggregate ambition expressed in the final NECPs;
- **MIX-nonCO2** variant of MIX which looks at a stronger contribution of non-CO₂ emissions to the GHG reduction objective, which translates into more reductions coming from non-CO₂ emissions and less reductions from CO₂ mostly in the energy system compared to MIX;
- **COVID-BSL** and **COVID-MIX** are two variants of BSL and MIX that include reduced economic growth assumptions due to the COVID-19 crisis and corresponding reduced activity in various sectors, including transport. COVID-BSL achieve the same climate and energy targets as BSL by 2030, while COVID-MIX achieves a reduction of 55% and is similar to the MIX scenario in terms of policy setup. While these two variants have been developed to reflect circumstances change due to COVID-19 crisis, the core of analysis is performed on scenarios developed without reflecting the crisis. At the time when analysis had to be concluded, too large uncertainties remained as to future macro-economic developments post COVID-19 crisis in order to develop sufficiently robust scenarios for the purpose of the key questions in this Impact Assessment.

All policy scenarios assume the full inclusion in the emission profile of net emissions from the LULUCF sector.

See Figure 3 for a stylised overview of the type of policy interaction included in some of the main scenarios. For a detailed description of the stylised climate, energy and transport policies included in the different scenarios, see annex 9.3.4.

Figure 3: Description of policy scenarios that look at interaction policies with the PRIMES-GAINS-GLOBIOM modelling suite

2030 Target Plan Policy Scenarios

	(REG) Policies and measures as main driver for GHG 55% target	(MIX)/ (MIX-50) Policies, measures and carbon pricing combined for GHG 55%/GHG 50% target	(CPRICE) Carbon pricing as main driver for GHG 55% target	(ALLBNK) Inclusion of all bunkers for GHG 55% target
Scope to assess GHG target ambition	All sectors including intra EU bunkers and LULUCF			
ETS Scope / Carbon Pricing	ETS scope: - Power, Industry, - Intra-EU aviation and navigation*	ETS scope: - Power, Industry, - Intra-EU aviation and navigation*, - Road transport, Buildings		All sectors including intra and extra EU bunkers and LULUCF ETS scope: - Power, Industry, - All aviation and navigation, - Road transport, buildings
EE policies	High intensification policies	Medium/low intensification policies	No additional measures compared to Baseline	Medium intensification policies
RES policies	High intensification policies	Medium/low intensification policies	No additional measures compared to Baseline	Medium intensification policies
Transport measures	High intensification policies (CO2 standards in road transport + RES, aviation and maritime fuel mandates + measures improving transport system efficiency)	Medium/low intensification policies (CO2 standards in road transport + RES, aviation and maritime fuel mandates + measures improving transport system efficiency)	Low intensification policies (CO2 standards in road transport + aviation and maritime fuel mandates + measures improving transport system efficiency)	Medium intensification policies (CO2 standards in road transport + measures improving transport system efficiency) High intensification of RES, aviation and maritime fuel mandates
non-CO2 policies	Medium intensification policies			
LULUCF policies	Baseline policies			

*Carbon pricing and carbon values are applied on extra EU aviation and navigation to represent ETS or other policy instruments regulating these sector's emissions (which can also stand for other policy instruments like CORSIA for aviation and technical and operational measures for both aviation and maritime).

Table 3 provides a mapping of the different policy options (see Table 2 for full overview of options related to the policy framework) as captured by the modelling scenarios described above that use the PRIMES-GAINS-GLOBIOM modelling tools.

Table 3: Policy options in the different detailed sectoral scenarios

Policy options in scenarios	BSL	MIX 50	REG	MIX	CPRICE	ALLBNK	MIX-nonCO2
Level of GHG target	GHG_1	GHG_2	GHG_3				GHG_3
Scope of GHG target	Scope_1	Scope_2				Scope_3	Scope_2
Role ETS and ESR, scope of carbon pricing	ETS_1	ETS_2.2	ETS_1	ETS_2.2	ETS_2.1	ETS_2.2	ETS_2.2
Renewable energy policies	RES_1	RES_2	RES_4	RES_3	RES_1*	RES_3**	RES_3****
Energy efficiency policies	EE_1	EE_2	EE_4	EE_3	EE_1	EE_3	EE_3
Transport policies	TRA_1	TRA_2	TRA_4	TRA_3	TRA_2	TRA_3***	TRA_3
LULUCF policies	LULUCF_1						LULUCF_1
Contribution of Non-CO2 emissions	NCO2_1	NCO2_2				NCO2_3	NCO2_3

*Notes: * includes also ReFuelEU aviation and FuelEU maritime initiatives as in RES_2; ** biofuels mandates in aviation and maritime sectors are closer to RES_4 (high ambition increase); *** alternative fuels mandates and some additional measures in aviation and maritime sectors are closer to TRA_4 (high ambition increase); **** all options in the MIX-nonCO2 variant are as in MIX, except for the renewables policy ambition that is slightly lower (but still higher than in MIX-50)*

By comparing the BSL, MIX-50, MIX one can assess the impact of 50% and 55% GHG emissions reduction targets. By further comparing with the ALLBNK scenario that achieves 55% GHG reduction including all aviation and navigation emissions in the GHG target scope one can look at the impact of a different scope on this ambition.

By comparing BSL, MIX-50, REG, MIX, CPRICE and ALLBNK one can look into how increased GHG ambition relates to renewables and energy efficiency ambition.

By comparing REG, MIX and CPRICE one can assess how energy and transport policies can interact with extending or not carbon pricing to additional sectors.

By comparing MIX and its variant MIX-nonCO2 one can analyse the role of a further contribution of non-CO₂ emissions to the overall GHG reductions objective.

This assessment is presented in detail in sections 6.1 to 6.5.

Section 6.1 look at how climate ambition (and target scope) relates to energy ambition.

Section 6.2 looks at what type of changes and action can be expected in different sectors to achieve higher climate and energy ambition. Section 6.2.1 looks in detail at the development in the energy system and the related CO₂ emissions. This covers also the material on transport (annex 9.4.2.6) and industrial sectors (annex 9.4.2.7). Section 6.2.2 looks at changes in the agriculture, waste industrial and energy sectors that impact specifically non-CO₂ emissions. Section 6.2.3 finally looks at the role of the LULUCF sector, notably how different scenarios impact bioenergy and wood demand and what the impact are on the sink and how it can be maintained or enhanced. Both sections 6.2.2 and 6.2.3 include additional quantitative assessments of options beyond those included in the scenario description as presented above.

Section 6.3, 6.4 and 6.5 include the more traditional assessment of environmental, economic and social impacts associated with the policy that is assessed, in this case the impact of achieving a reduction of GHG emissions in the range of 50% to 55% by 2030 with a particular important role for the energy system in delivering that increased ambition.

Section 6.4 on GDP and competitiveness and section 6.5 includes impacts on employment. For this specific macro-economic modelling tools are used (the JRC-GEM-E3, QUEST and E3ME

models) which use results of the PRIMES energy model (final consumption, energy mix changes and related investments requirements per sector, etc.) as an input to determine the impact on macroeconomic aggregates as well as on individual sectors of the economy (see annex 9.3 on the methodology used). This approach allows estimating the impact on employment and GDP of the different climate ambitions and different policy options as far as meaningful differences can be distinguished. The macroeconomic models are also used to test variants not captured by the main energy scenarios.

In order to estimate the impact of the European Green Deal's climate ambition on the competitiveness of the European economy, it is necessary to evaluate what the impacts would be if some of our international partners do not implement ambitious climate plans. For this purpose, two scenarios were modelled reflecting different global trends. A Fragmented Action scenario in which the EU reaches the Green Deal climate targets and the rest of the world implements only their Nationally Determined Contributions. A Global Action scenario in which the EU reaches the Green Deal targets and the rest of the world follows on a trajectory compatible with the 1.5°C Paris Agreement target. This also allowed to assess the impact on carbon leakage and the need or not to implement a carbon border adjustment mechanism to reduce the risk of carbon leakage.

Separate analysis was carried out with the macroeconomic models to estimate the distributional impacts of the increased climate targets and verify that policy measures do not weight excessively on lower income EU citizens.

Scenario variants were also developed to investigate the effect of using ETS revenues for different purposes (to provide a lump sum transfer to consumers or to reduce labour taxes).

Finally section 6.4.3 zooms in specifically on the economic impact of the COVID-19 crisis on achieving higher GHG reductions by comparing the COVID-MIX scenario to the MIX scenario, both achieving a 55% GHG reduction by in strongly different economic circumstances.

Section 6.6 to 6.10 are assessing in a more qualitative manner the role of different policies in achieving this increase climate and energy ambition. Section 6.6 focusses on renewable energy, energy efficiency and transport policy and section 6.7 on the role of expanded carbon pricing tools as well as the existing ESR. Section 6.8 discusses interaction between energy and climate policies. Section 6.9 discussed the impact on carbon leakage of increased ambition taking into account the present measures to prevent carbon leakage. Section 6.10 discusses the use of the LULUCF regulation and its interaction with other policy tools such as the ESR and ETS to enhance further the LULUCF sink. Finally while not really assessing specific policy options, annex 9.11 discusses the critical role of the wider enabling framework of EU policies to achieve deeper GHG reductions.

6 WHAT ARE THE IMPACTS OF INCREASING GHG AMBITION IN THE RANGE OF 50% TO 55% REDUCTIONS BY 2030?

6.1 Relationship among climate and energy efficiency and renewable policy ambition levels

This section assesses combinations of increased GHG emissions reduction target and ambition levels for energy efficiency improvements and renewable energy deployment, as well as the impact of a different scope of the GHG reduction target on the necessary GHG reduction level in different sectors.

The achieved combinations are modelled with an energy system model, expanded by non-CO₂ and land use modelling, which ensures that they are coherent and that key interactions (overlaps, synergies and trade-offs) are considered. The levels of ambition for energy efficiency and renewables are outcomes of scenarios modelling relevant policies (REG), interaction of such policies with carbon pricing (MIX) or carbon pricing (CPRICE), in combination with different intensification of transport policies. ALLBNK shares similar policy instruments as in MIX, but more intensified notably in terms of transport fuel mandates in order to meet the increased GHG ambition due to inclusion of extra-EU aviation and navigation in the scope of GHG emissions

6.1.1 Impacts of the scope of the GHG target

Table 4 shows the achieved GHG reductions for two different scopes of target (corresponding to policy options in section 5.2.1.1 for a set of scenarios with different GHG ambition. As explained in section 5.2.1.1 to assess pathways to climate neutrality and establish how the EU economy progressing to achieve net zero GHG, it is the GHG profile including the net LULUCF sink that is used.

Scenarios MIX-50 and MIX achieve respectively a bit more than 50% and 55% GHG reductions compared to 1990 by 2030 for all sectors including intra EU aviation and navigation emissions, but not if extra EU aviation and navigation emissions are included as well.

ALLBNK does achieve just over 55% also including extra EU aviation and navigation emissions. This scenario thus requires to reduce more GHG emissions in the domestic sectors excluding extra EU aviation and navigation as these two sectors achieve only limited GHG reductions compared to domestic sectors. The impact would be to increase required reductions in the domestic sectors by around 3 percentage points to almost -58%¹⁰¹.

Table 4: Impact of scope of international bunker fuels on total GHG emission reductions for different scenarios

Scope	BSL	MIX-50	MIX	ALLBNK
GHG reductions by 2030 compared to 1990 including the net LULUCF sink				
Including intra EU aviation and maritime navigation	-46.9%	-51.0%	-55.0%	-57.9%
Including intra + extra EU aviation and maritime navigation	-43.8%	-48.1%	-52.1%	-55.1%

¹⁰¹ This estimate is based on an estimate of international navigation emissions based on bunker fuels sold in the EU, comparable to the memo item as reported in the EU greenhouse gas inventory reported to the UNFCCC. The emission scope for any regulation that may be based on specific monitoring, verification and reporting requirements is likely to have a less large scope and thus a somewhat reduced impact.

While international aviation is fully included in the EU ETS, the current international context has led the EU to temporarily limit the scope of the EU ETS to flights between two EEA member states, pending international developments as regards extra-EEA flights (CORSIA). For both aviation and navigation international bunker fuels, international discussions are ongoing in the context of ICAO and IMO.

The EU will need to carefully consider its own measures, next to any global action. Independently from the option retained, the EU will continue to play a key role in incentivising ambitious global action for the decarbonisation of the two sectors. Therefore this Impact Assessment assumed that even in scenarios where the extra-EU scope of the maritime and aviation sectors is not included in the EU GHG target, a combination of a carbon value¹⁰², a carbon price and/or fuel mandates apply to these sectors. These represent both EU policies, as well as, potentially, an effective mix of global policies. The net LULUCF sink is included in a conservative manner, with projections that follow estimated emissions and removals corresponding to the recently agreed Forest Reference Levels and assuming the achievement of the “No Debit” rule for other land categories (see also section 6.2.3).

6.1.2 Impacts on renewables share and energy efficiency ambition levels

Table 5 portrays combinations of renewable energy¹⁰³ and energy efficiency ambition levels (both in primary and in final energy consumption¹⁰⁴) resulting from achieving a certain level of 2030 GHG emissions reductions as analysed in the scenarios. With the energy system responsible today for just over 75% of emissions, renewable energy deployment and energy efficiency are the single largest contributors to GHG reductions¹⁰⁵.

The scenario achieving around 50% GHG target (including intra EU aviation and navigation emissions in the target scope) achieves 35% for RES share and 34.5% of final energy savings and 37% of primary energy savings. The scenarios achieving 55% GHG ambition (including intra EU aviation and navigation emissions in the target scope) arrive at the RES share of between 37.5% to 39%, final energy savings between 36% to 36.5% and primary energy savings between 39% to 40%. Somewhat less ambition is required in the MIX-nonCO₂ variant that achieves more reductions in non-CO₂ emissions.

Conversely, the ALLBNK scenario that achieves 55% GHG reductions (including intra and extra EU aviation and navigation in the target scope) also achieves a higher RES share of 40.5% and higher 37% of final energy savings and 40.5% primary energy savings.

Combinations of policy instruments considered in the different scenarios achieving the same 55% GHG target deliver only limited differences in energy savings and renewable energy shares. Scenario REG, focusing more on regulatory measures driven by more ambitious energy efficiency, renewables and transport policies, performs strongest in energy savings (both in primary and final energy consumption) and in renewable energy deployment. Scenario CPRICE, driven mainly by a strong carbon price (that represents incentives for fuel substitution) extended to a large part of the EU economy, but also some transport measures, including CO₂ vehicle

¹⁰² A carbon value can represent other policy instruments than carbon pricing, like CORSIA for aviation and technical and operational measures for both aviation and maritime navigation.

¹⁰³ Expressed in the same way as currently legislated 32% target, i.e. as share in gross final energy consumption.

¹⁰⁴ Expressed in the same way as currently legislated 32.5% target, i.e. as reductions achieved compared to 2007 Baseline

¹⁰⁵ The scenarios also take into account national policies towards coal phase and nuclear deployment. These policy levers remain the national prerogative (with the exception of EC competences, such as those indicated in the EURATOM Treaty in the case of nuclear energy).

standards and fuel obligations for aviation and navigation, delivers the GHG reductions through fuel mix changes. Finally, scenario MIX delivers a balanced performance across the different policy measures.

The results thus indicate rather convergent pathways for the overall ambition levels to reach the desired GHG emissions reduction ambition. The following chapters will look into the specific characteristics of each scenario and their performance across different sectors.

Table 5: Interaction of the 2030 GHG ambition with renewable energy share and energy savings

Scenarios	Total GHG vs 1990 ¹⁰⁶	Renewables share ¹⁰⁷ Overall	Energy savings ¹⁰⁸	
			Primary energy consumption ¹⁰⁹	Final energy consumption ¹¹⁰
BSL	-46.9%	32.0%	-34.2%	-32.4%
MIX-50	-51.0%	35.1%	-36.8%	-34.4%
REG	-55.0%	38.7%	-40.1%	-36.6%
MIX	-55.0%	38.4%	-39.7%	-35.9%
CPRICE	-55.0%	37.9%	-39.2%	-35.5%
ALLBNK	-57.9%	40.4%	-40.6%	-36.7%
<i>Variant MIX-non-CO₂</i>	<i>-55.1%</i>	<i>37.5%</i>	<i>-39.3%</i>	<i>-35.9%</i>

Feedback received through the open public consultations highlights broad support for increase of climate and energy targets, 77% of all answers supported an increase of the target to at least 55% GHG reductions. 88% of EU citizens supported this level while for replies received in a professional capacity this was 55% (with 23% of replies received in a professional capacity supporting an increase to least 50% GHG reductions). Business associations and companies show a more equal rating of options, with the highest GHG reduction option still having the highest support rate. NGOs in their overwhelming majority support an increase in the GHG ambition of at least 55%.

A similar picture emerges for the renewable energy and the energy efficiency ambitions for the highest ambition of a higher than 40% renewable energy share in final energy consumption, and a higher than 40% energy efficiency contribution which were supported respectively by 69% and 62% of all answers. Of the replies received in a professional capacity 39% support the highest ambition option for renewable energy and 26% for energy efficiency. The overwhelming majority of NGOs again support increases to both the renewable energy and the energy efficiency ambition. Business associations and companies show a more balanced rating of options.

Annex 9.2 contains detailed data on how each stakeholder type responded on the ambition in greenhouse gas reductions and the accompanying energy policies, as well as on the associated

¹⁰⁶ Including net LULUCF and including intra EU aviation and navigation

¹⁰⁷ Share of RES in gross final energy consumption according to 2009 RES Directive.

¹⁰⁸ Energy Savings evaluated against the 2007 Baseline projections for 2030.

¹⁰⁹ It corresponds to the EUROSTAT indicator PEC (2020-2030)

¹¹⁰ It corresponds to the EUROSTAT indicator FEC (2020-2030)

opportunities and challenges. Moreover, a number of campaign contributions were identified, though these do not materially alter the conclusions on preferred options.

6.2 Sectoral transitions to achieve 50% to 55% GHG reductions

Table 6 presents the projected reductions compared to 2005 for all main sectors for all the scenarios assessed.¹¹¹

Overall energy supply side emissions reduce most, underlining the remaining large reduction potential through deployment of renewable energy in the power sector. From the demand side sectors, reductions are highest in the residential sector, followed by the services sector with much more limited scope in the next decade for industry and transport. Large scope of emissions reductions potential remains for the EU building stock that is relatively old and inefficient. For the industrial and transport sectors lower emission reductions are projected for the next decade but much higher reduction rates after 2030. This actually underlines how crucial the next 10 years will be to develop and deploy new climate neutral technologies at scale, and decrease learning costs, just as was done for renewable electricity in the last decade. Non-CO₂ emissions reduce less than CO₂ emissions with notably the largest part of it - agriculture sector - being responsible for lesser rates of reductions.

¹¹¹ In the public consultation, the sectors rated by the respondents as important to increase the 2030 GHG emissions target were energy supply (48%), mobility and transport (16%), industry (13%), and buildings (7%).

Table 6: Sectoral GHG emissions and reductions depending on different scenarios

	BSL	MIX-50	REG	MIX	MIX-non-CO ₂ variant	CPRICE	ALLBNK
	% change 2030 GHG emissions versus 1990						
Total GHG incl. LULUCF¹¹²	-46.9%	-51.0%	-55.0%	-55.0%	-55.1%	-55.0%	-57.9%
Total GHG excl. LULUCF	-45.1%	-49.0%	-52.8%	-52.8%	-52.8%	-52.8%	-55.5%
	% change 2030 GHG emissions versus 2015						
CO ₂ emissions	-32.7%	-37.7%	-42.7%	-42.6%	-41.9%	-42.6%	-46.0%
Supply side ¹¹³	-50.3%	-58.0%	-67.3%	-67.5%	-65.7%	-67.5%	-73.1%
Power generation ¹¹⁴	-53.0%	-60.8%	-69.6%	-70.8%	-68.7%	-70.4%	-76.1%
Industry ¹¹⁵	-18.2%	-20.3%	-21.0%	-22.4%	-22.1%	-23.3%	-25.1%
Residential	-47.2%	-56.5%	-63.6%	-62.0%	-61.9%	-61.0%	-64.8%
Services	-48.7%	-56.5%	-53.5%	-57.8%	-58.1%	-60.4%	-60.6%
Agriculture energy	-30.5%	-36.3%	-37.0%	-37.3%	-37.4%	-37.7%	-39.2%
Transport	-12.5%	-14.9%	-17.6%	-16.3%	-16.4%	-15.6%	-17.7%
Of which Road Transport	-16.4%	-18.3%	-20.7%	-19.6%	-19.6%	-18.9%	-20.6%
Intra EU aviation & navigation	23.5%	16.7%	11.6%	13.7%	13.7%	14.4%	8.5%
Non-CO ₂ emissions	-22.3%	-26.7%	-31.0%	-31.0%	-34.5%	-31.0%	-34.5%

¹¹² Including domestic and intra EU aviation and maritime navigation

¹¹³ Power sector, district heating, energy branch and refineries

¹¹⁴ Excluding district heating

¹¹⁵ Including process CO₂ emissions from industry, excluding refineries

6.2.1 Energy system

6.2.1.1 Evolution of GHG emissions from the energy system

By contributing currently just over 75% of total GHG emissions in the EU, including the non-CO₂ emissions from the energy system, the energy sector contributes the largest amount of total reductions.¹¹⁶

GHG emissions from the energy system decrease by 36% by 2030 compared to 2015 in BSL and by over 45% in the policy scenarios achieving 55% GHG reductions¹¹⁷. Non-energy related emissions only decrease by less than 20% in the policy scenarios over this period. This is notably because CO₂ emissions from combustion decrease faster than CO₂ process emissions in the industrial sectors and it is likewise for non-CO₂ emissions from other sectors than the energy system.

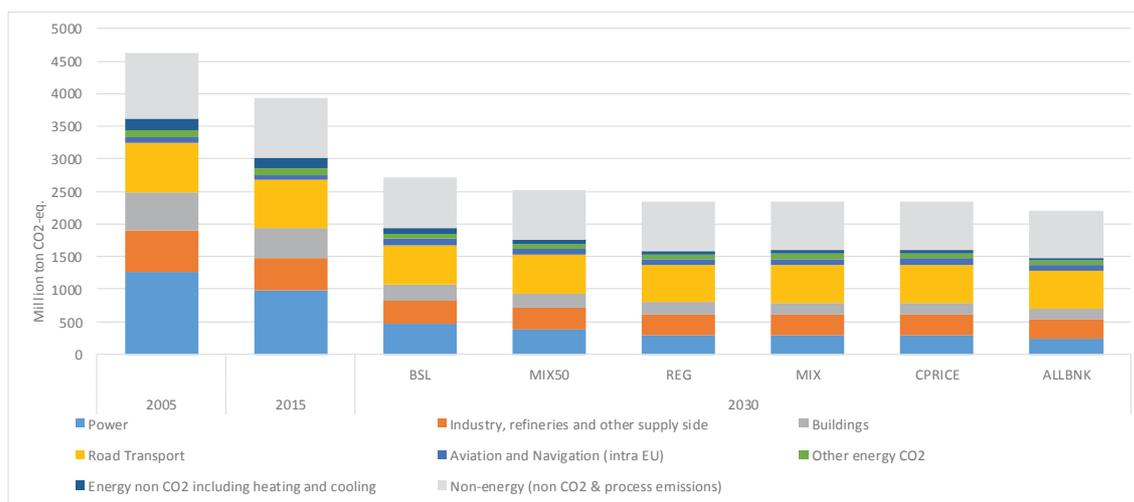
Between 2005-2015 on average reductions of 59 MtCO₂-eq took place annually in the energy system. A significant step-up needs to be achieved. In BSL this increases in the period 2015-2030 to 73 MtCO₂-eq, going to 84 MtCO₂-eq in MIX-50 and to around 95 MtCO₂-eq in REG, MIX, and CPRICE (see Figure 4). Highest reduction are projected in ALLBNK, seeing an annual reduction in the energy system of just above 100 MtCO₂-eq.

Significant differences exist between sectors. Buildings and the power sector see the projected annual average reduction grow by more than half and achieve in total a reduction 60% and more between 2015 and 2030. In road transport annual CO₂ emissions reduction double compared to the period 2005-2015 but the sector still sees only a decrease in emissions of 20% in the period 2015-2030. In industry, however, the projected annual reduction in energy CO₂ emissions decreases somewhat compared to the decade 2005-2015.

¹¹⁶ The respondents to the public consultation rated higher penetration of renewable energy, decreasing energy use due to life-style changes, the phase-out of solid fossil fuels, and higher energy efficiency as the main drivers were necessary for the energy transition to facilitate the 2030 GHG emission reduction target. The least voted drivers were the use of Carbon Capture and Use (CCU) technologies, the use of nuclear energy for power generation, and better sector coupling between gas and electricity.

¹¹⁷ GHG emissions including domestic and intra EU aviation and maritime navigation.

Figure 4: Sectoral GHG reductions, focus on energy system emissions



Source: PRIMES model, GAINS model

6.2.1.2 Evolution of the energy mix and demand

The first conclusion that can be drawn from the analysis is that achieving 50-55% GHG reductions in 2030 would require significantly lower total energy demand (gross inland consumption) compared to BSL. After 2030, the uptake of energy intensive new fuels¹¹⁸ including hydrogen¹¹⁹, e-gas and e-liquids, would lead to a slight increase in gross energy consumption (see Figure 5)¹²⁰.

The energy mix in 2030 would remain dominated by fossil fuels overall, but renewables increase significantly in all policy scenarios and more so than in BSL. The contribution of nuclear energy remains relatively stable, resulting from the operation of existing nuclear power plants and the commissioning of new plants. By contrast, the use of fossil fuels – coal, oil and natural gas is projected to decrease significantly more than in BSL. These projected evolutions are in line with scenarios from third parties¹²¹.

By 2050, the trends observed by 2030 are greatly amplified. The growth of renewables is dramatic, more than tripling compared to 2015¹²², while fossil fuels represent in 2050 only 10-11% of the GIC in energy uses, complemented by non-energy uses¹²³.

¹¹⁸ By convention, both the production of e-gas and e-liquids and the inputs for this production are accounted for in gross inland energy consumption.

¹¹⁹ The policy scenarios considered see a ramp up of the installed electrolyser capacity between 37-66 GW by 2035, responsible for a production of up to ca. 8 Mt of hydrogen in 2035.

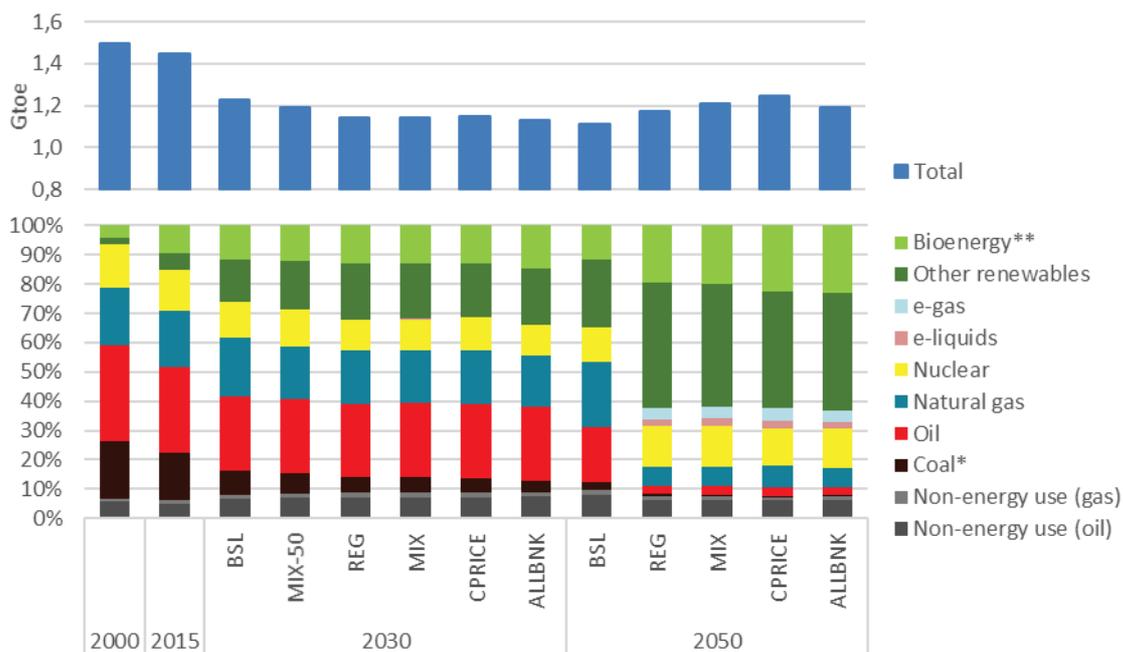
¹²⁰ The effect is more visible in CPRICE scenario as new fuels are developing stronger in that scenario.

¹²¹ See: Tsiropoulos I., Nijss W., Tarvydas D., Ruiz Castillo P., Towards net-zero emissions in the EU energy system by 2050 – Insights from scenarios in line with the 2030 and 2050 ambitions of the European Green Deal, EUR 29981 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-13096-3, doi:10.2760/081488, JRC118592.

¹²² While biomass would double by 2050, other renewables would grow sevenfold compared to current level.

¹²³ Compared to the Baseline, natural gas reduces most (up to 80% lower).

Figure 5: Energy gross inland consumption



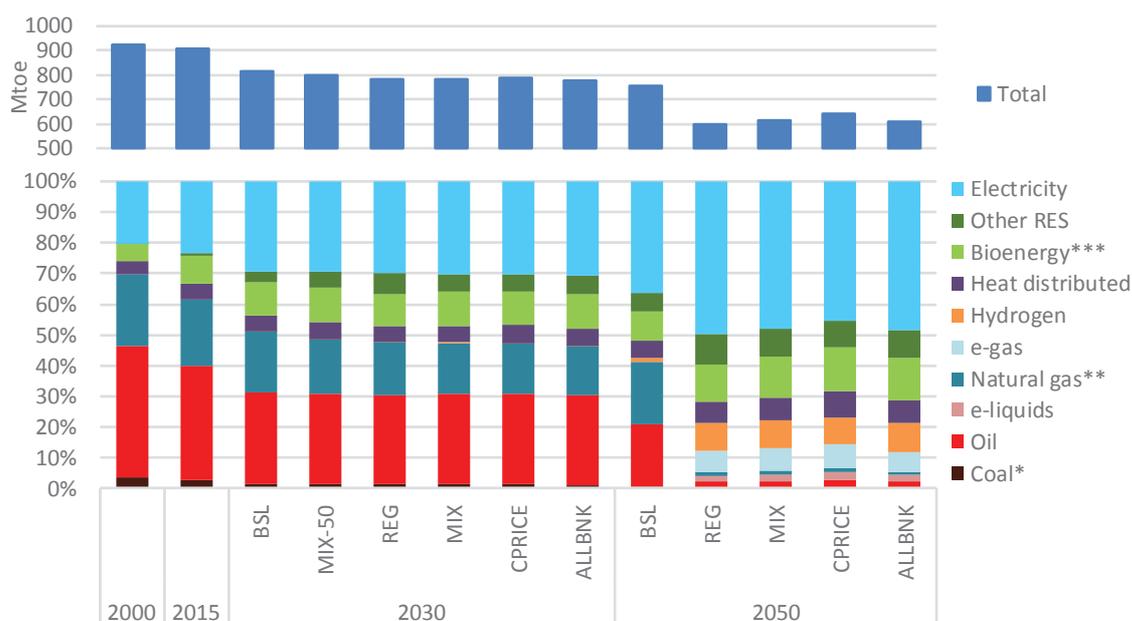
Note: * includes peat, oil shale, ** includes waste

Source: 2000, 2015: Eurostat, 2030-2050: PRIMES model

The evolution of the gross inland consumption follows the evolution of final energy consumption (FEC).¹²⁴ The FEC declines in all scenarios but slightly more strongly in REG and MIX than in CPRICE as the latter depends less on moderation of energy demand in different sectors but features more of fuel switching. The overall fuel mix for final demand changes progressively (Figure 6) and the specific sectoral drivers and dynamics are described in the relevant annexes.

¹²⁴ A majority in the public consultation perceived that an increase to greater than 40% for energy efficiency by 2030 was required. This is driven mainly by the opinion of individuals rather than professional respondents.

Figure 6: Final energy demand by energy carrier



Note: * includes peat, oil shale, ** includes manufactured gases, *** solid biomass, liquid biofuels, biogas, waste

Source: 2000, 2015: Eurostat, 2030-2050: PRIMES model

The following general trends can be noticed. First of all, coal becomes marginal in final energy demand in 2030, driven by reductions in industry and the declared policies in a number of Member States to reduce coal for heating purposes, as well as the required increase in uptake of renewables in BSL to achieve the renewable energy target of 32% by 2030. Oil and natural gas remain significant contributors to the final energy demand (reaching 29-30% and 16-17% share respectively in 2030), albeit at lower level compared to today (37% and 22%, respectively in 2015). By 2050, the situation changes radically. Oil and natural gas consumptions are reduced to a fraction of current levels in the policy scenarios, while they are still important in BSL. They are partially substituted by new renewable and low-carbon fuels, mainly of gaseous form (and to a lower degree of liquid form). These types of energy vectors would retain an important role in satisfying the energy needs of the economy in the long term, building on an increasingly integrated energy system¹²⁵.

On the other hand, the contribution of electricity in final demand is further accelerated in some applications in the policy scenarios. This increase is driven by the uptake of heat pumps in buildings, the electrification of industrial processes as well as the further electrification of transport, while other forms of electricity consumption see reductions due to energy efficiency improvements. The direct contribution of renewables in final energy demand also increases significantly.

¹²⁵ The EU Strategy on Energy System Integration further elaborates on the linking of multiple energy carriers, infrastructures, and consumption sectors as an enabler for a greenhouse gas neutral energy system for the EU.

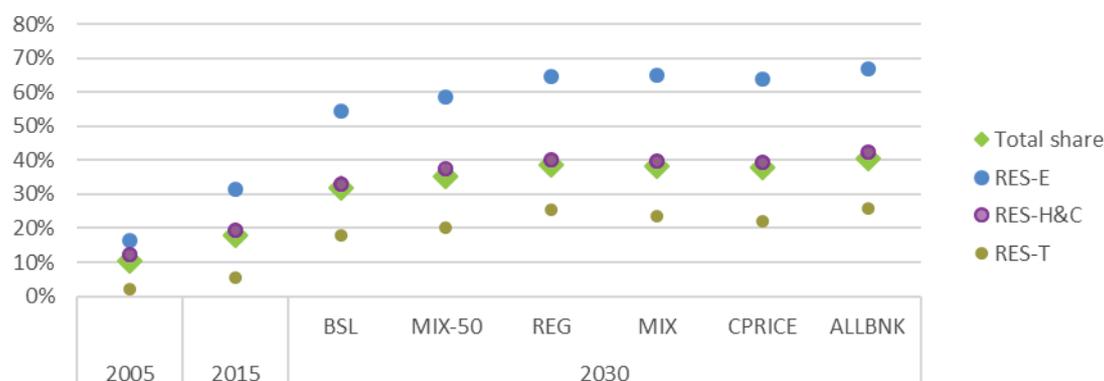
Energy demand in the residential sector undergoes the highest reduction by 2030 triggered notably by the strengthening of dedicated policies and measures (see detailed assumptions in annex 9.3.4).

The relative sectoral evolutions lead to a changing sectoral composition of the final energy demand, with industry and services becoming relatively more important over time, while residential and transport are declining. For a complete discussion of the evolution of the overall energy mix and demand, see annex 9.4.2.1.

6.2.1.3 Renewable energy supply and demand

The increases of RES are observed in all major demand sectors – electricity, heating and cooling and transport - over the whole period analysed and compared to BSL as illustrated in Figure 7.

Figure 7: Renewables shares



Source: PRIMES model

By 2030, the electricity sector will see the highest share of renewables with 55% in the BSL scenario and over 60% in the policy scenarios, driven by a combination of much more ambitious renewables policies (REG) and/or a further increase in the ETS carbon price (CPRICE) or a combination of policies (MIX and variants). This implies that substantial acceleration, compared to observed trends of renewable electricity growth of 3% per year observed over 2010-2018, will be needed. Lowering the 2030 GHG reduction ambition leads to a RES-E share of 58% in MIX-50. In the ALLBNK scenario, the RES-E share reaches 67%.

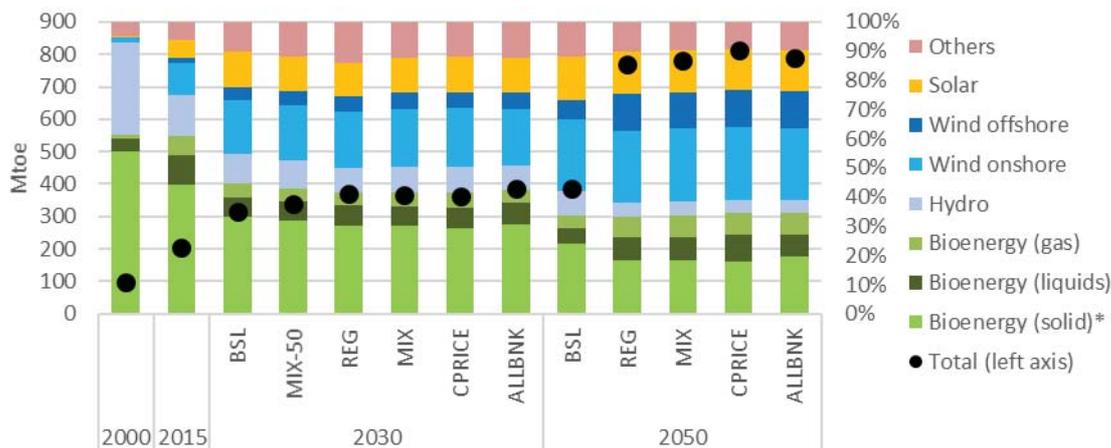
By 2050, renewables in power generation are projected to more than 85% in 2050. This implies that substantial acceleration, compared to observed trends of renewable electricity growth of 3% per year observed over 2010-2018, will be needed.

During the same time period, the share of renewables in the heating and cooling sector (“RES-H&C”) will increase to 33% in BSL in order to achieve the existing 2030 RES target and 39-40% in the policy scenarios to contribute to the increased GHG ambition. This reduces to 37% in the MIX-50 scenario while the ALLBNK scenario sees a RES-H&C share of 42%. The annexes on buildings (annex 9.4.2.5) and on industry (annex 9.4.2.7) provide more information on the developments in the heating and cooling sector.

Of all sectors, transport has, in 2015, the lowest penetration of renewables with a share (“RES-T”) of 6%¹²⁶. By 2030, this increases to 18% in BSL and to 22% (CPRICE) - 26% (REG) in the main policy scenarios. The MIX-50 scenario achieves 20% (2 p.p. less than CPRICE) while in the ALLBNK scenario this share reaches the same level as in REG. Annex 9.4.2.6 provides more detail on the development in the transport sector.

The portfolio of renewable energy supply options is getting more diverse both in BSL and in the policy scenarios. The share of biogenic sources, currently the single largest contributor, and of hydropower will decrease, while that of wind and solar energy will increase.

Figure 8: Renewable energy production



Note: includes biofuel production for international air and maritime bunkers

Source: 2000, 2015: Eurostat, 2030-2050: PRIMES model

For a more detailed focus on the evolution of renewable energy supply and demand, please see annex 9.4.2.2.

Detailed sectoral overviews on how the energy transformation impacts specific sectors can be found in annexes 9.4.2.3 to 9.4.2.7 addressing respectively the electricity, gas, buildings, transport and industrial sectors.

6.2.2 Non-CO₂ greenhouse gas emissions, sectors and mitigation potential

Significant quantities of non-CO₂ greenhouse gases are still being emitted in the EU today, representing around 20% of total emissions. In 2015, methane represented around 60% of total non-CO₂ greenhouse gas emission, followed by nitrous oxides and F-gas emissions. Agriculture was the largest emitting sector, representing around 50% of non-CO₂ emissions, followed by energy (including F-gas emissions from heating and cooling installations) and waste at equal levels. In baseline non-CO₂ emissions are projected to decrease though at a slightly lesser rate than CO₂ emissions, with largest reductions being achieved in the waste sector due to EU waste legislation and the energy sector with F-gas regulations impacting emissions from heating and

¹²⁶ According to Articles 25-27 of Directive 2018/2001/EC (revised RED) where specific caps and multipliers apply for different renewable fuels. If the share was to be calculated according to the methodology in Directives 2009/28/EC and 2015/1513/EC (RED up to 2020) it would be equal to 7%.

cooling and emissions reducing due to reduction of extraction and consumption of fossil fuels in the EU.

There is still significant mitigation potential beyond baseline in these sectors. Annex 9.4.3 gives a detailed overview of this mitigation potential per greenhouse gas and sector. Some of this mitigation potential may come at a win-win and thus low cost, such as avoided methane leaks in gas distribution systems or breeding for increased health and fertility in cattle. If fully achieved it would lower non-CO₂ emissions by 29% by 2030 compared to 2015. But while the marginal abatement costs may be estimated at zero or even negative costs, policy intervention will be needed to overcome market barriers, lack of information and split incentives. The largest share of this low cost potential is located in the energy sector, and is notably related to capturing fugitive methane, underlining the importance of concrete action in this domain.

The MIX-50 scenario achieving 50% overall GHG reductions uses partially this available low cost potential while the scenarios MIX, REG and CPRICE use most of it. The latter is presented by the Moderate contribution scenario in the below Figure 9 covering option NCO2_2.

The high contribution scenario instead projects the increased mitigation potential at carbon values of €55/tCO₂-eq (equivalent to carbon prices as projected in REG and MIX) covering option NCO2_3. This would reduce non-CO₂ emissions by 34% by 2030 compared to 2015 notably through further reduction in the energy and agriculture sectors. If this is level of non-CO₂ mitigation is achieved, it could in principle allow for taking less action on RES and EE (MIX-nonCO₂ variant) to achieve the same 55% GHG reductions or allow to contribute to even higher overall GHG reduction ambition (ALLBNK). Most of non-CO₂ emissions are regulated by the Effort Sharing Regulation, so part of this choice is in the remit of Member States.

These mitigation potentials are quantitatively shown in Figure 9 below. Depending on whether the moderate contribution or high contribution option is achieved, the effort needed in other sectors can change. For instance, the 55% GHG reductions in MIX-nonCO₂ can be achieved with somewhat less effort in energy efficiency and renewable energy than in MIX (see section 6.1.2). Also impacted are the relative contributions of the ETS and ESR sectors, with MIX-nonCO₂ reducing more ESR emissions than MIX, and vice versa for the ETS sectors (see section 6.7.1).

Figure 9: Sectoral non-CO₂ greenhouse gas emission reductions

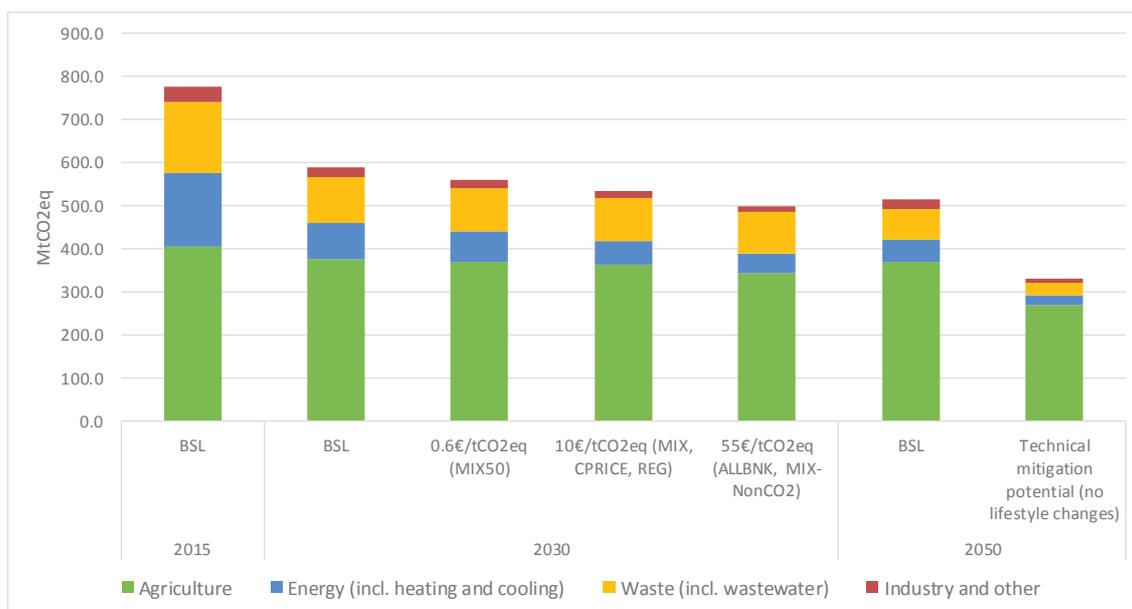


Figure 9 also underlines that the key importance of further reducing non-CO₂ emissions towards 2050, which will be crucial to limit the need for net removals in order to achieve net zero GHG, with a difference of over 150 million tonne of removals saved if the technical mitigation potential in non-CO₂ would be achieved by 2050.

Even higher mitigation potentials as presented in Figure 9 can be achieved with additional efforts in the agriculture sector (option NCO2_3). These are discussed in annex 9.4.3. Reduced emissions from fertiliser application through reduction of excess fertiliser and manure application and through the introduction of nitrification inhibitors are examples. Notably the Biodiversity Strategy has set the goal of zero pollution from nitrogen and phosphorus flows from fertilisers through reducing nutrient losses by at least 50%, which would strongly contribute to this mitigation potential.

In this context it is important to note that the scenario assessment in this section does not include the impact of potential lifestyle changes, notably related to healthy diets, which could also further reduce emissions and limit the need by 2050 of equivalent removals. Annex 9.4.3 gives quantitative insights in what this could contribute to.

6.2.3 *The Land Use, Land Use Change and Forestry Sector*

Since 1990, the land use and forestry sector has removed from the atmosphere an average of 300 MtCO₂-eq annually with inter-annual variations ranging from 250 MtCO₂-eq in 1992 to 336 MtCO₂-eq in 2006. In 2013 the sink stood at 324 MtCO₂-eq while in 2018, the last reported year in the UNFCCC inventories, the sink removed 264 MtCO₂-eq from the atmosphere, a significant reduction over 5 years. Forest areas are responsible for most of the variability in the inventories of the EU LULUCF sink. Wood harvest for both material and energy purposes, forest ageing and natural hazards drive most of the variations of the forest removals. Annex 9.4.4 contains a more detailed discussion on past variability of the sink per land category.

Biomass demand is often associated with potential impacts on the land use sink. Power generation and residential heating today make up most of the biomass demand for energy. By 2030, changes in projected biomass demand in the scenario applied for this assessment are not significant, while by 2050 these will be larger with the power sector more than a doubling its use of bioenergy notably to generate negative emissions. In this time-frame, coupling the use of solid biomass with CCS installations in power and industry sectors would contribute to the removal of CO₂ from the atmosphere. The decarbonisation of road, maritime and air transport requires advanced biofuels that need to be produced at scale after 2030. Nevertheless it would not represent more than 20% of the total use of biomass in any of the scenarios. Of key importance in this context will be to make the shift away from biofuels relying on food and feed crops to advanced biofuels produced from woody energy crops and a better mobilisation of agricultural residues and biomass waste in our household and industrial waste streams. Otherwise, the impact on land use demand and the LULUCF sink will be more pronounced. See annex 9.4.4 for more detail.

The limited variations across the scenarios in the use of biomass for bioenergy by 2030 are not projected to be a major driver of changes in the composition and level of the EU LULUCF sink across the Baseline and various policy scenarios MIX, REG, CPRICE and ALLBNK.

More differentiation in the size of the natural sink could come from the degree of intensity of Members States' efforts to impact the LULUCF sink and the capacity of the EU and its Member States to incentivise action at farmers or foresters level. Figure 10 presents the levels of removal that the EU could reach in any of the scenarios under various assumptions in terms of LULUCF action.

EU emissions and removals from forest management and harvested wood products are projected to decrease, following the recently agreed Forest Reference Levels¹²⁷. Assuming that both the forest sector as well as other land categories would follow a “No Debit” scenario, the natural sink would be as low as -225 MtCO₂-eq by 2030.

The “FRL” scenario similarly sets the emissions and removals from forest management at the level of the recently agreed Forest Reference Levels¹²⁸ but follows for the other LULUCF land categories the GLOBIOM model projections, which are more optimistic that deforestation, afforestation and other land use change will improve and result in 2030 in total net LULUCF removals at almost -260 MtCO₂-eq, a level similar to 2018 removals.

The “MIX” scenario relies only on GLOBIOM estimates. For bioenergy demand it uses the demand as projected in the MIX PRIMES energy scenario. For other material demand it uses GLOBIOM assumptions. This scenario is more optimistic and projects that the recent decrease observed in LULUCF removals is not representative of the long-term trend and in 2030 the natural sink would be back to 2015 levels (-295 MtCO₂-eq).

In the “LULUCF+” scenario, initiatives at EU, Member State or regional level have been developed that enable action at local level to enhance the LULUCF sink to approximately -340 MtCO₂-eq by 2030, close to the 30-year maximum sink observed in 2006. Actions can include optimisation of forest management, afforestation projects and improving soil management including through rewetting and restoration. By 2050 in the scenario, agricultural land is no longer a net LULUCF emitter and the forest land is removing substantially more CO₂ from the atmosphere. The entire LULUCF sector could then balance about 425 MtCO₂-eq of residual emissions from other sectors to enable the EU, to be climate neutral by 2050. A detailed discussion on the type of actions that can be taken is included in annex 9.4.4.

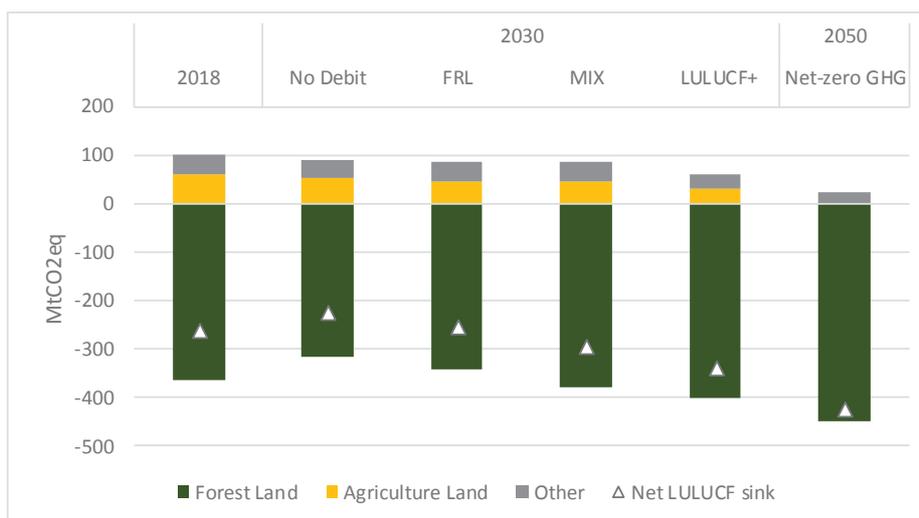
Where the sink will be in 2030 will depend on several variables. Increased harvesting (No Debit and FRL scenarios) or a continued increase of natural hazards, in part due to climate change itself (see also annex 9.4.4 for a discussion on the risk of increased disturbance and the need to adapt to climate change), may indeed reduce the sink. On the other hand projections based on the PRIMES and GLOBIOM modelling tools themselves (MIX scenario) would be more optimistic about the sink. Finally actions can be taken to expand it (LULUCF+ scenario).

This latter scenario appears to represent particularly well the likelihood that net zero GHG emissions can be effectively achieved by 2050. Section 6.10 will look into which climate policy tools can contribute to such an outcome, and how this relates to the overall GHG reduction ambition and efforts in the ESR and ETS sectors.

¹²⁷ [Annex of the draft delegated act](#) 22 June 2020 - Commission expert group on Land Use, Land Use Change and Forestry (LULUCF)

¹²⁸ Ibid.

Figure 10: CO₂ emissions and removals in the LULUCF sector



Source: UNFCCC inventories, GLOBIOM model

6.3 Environmental impacts of achieving combination of GHG/RES/EE ambition levels

6.3.1 Air pollution and health

Reductions in GHG emissions of different decarbonisation scenarios have positive impacts on air pollution because of the reduction in energy consumption and a shift to non-emitting renewable energy sources. The analysis is based on the GAINS model. This permits a broad estimation of changes in air pollution impacts, air pollution control costs as well as health impacts. The analysis was carried out for both baseline and policy scenarios. Table 7 shows that in BSL due to a combination of climate, energy and air pollution policies SO₂ emissions are reduced by 62%, NO_x by 56% and PM_{2.5} by 47% compared to 2015. Reducing GHG emissions in 2030 by 55% (MIX) will reduce emissions of PM_{2.5}, NO_x and SO₂ in the EU further by about 4%, 7%, and 17%, respectively in 2030 compared to the baseline. Combined air pollution reduces by 60% by 2030 compared to 2015 in scenarios achieving 55% GHG reductions.

The reduction in air pollution has positive impacts on human health. Table 7 shows the impacts on mortality. The number of premature deaths due to PM_{2.5} emissions in the EU drops by 5020 in 2030 compared to baseline. In addition, the number of premature deaths due to ground level ozone drops by 254 cases per year by 2030 (see Table 7). In specific locations air quality may however deteriorate. The reduction in GHG emissions also reduces the costs of controlling other air pollutants. Table 7 shows that a 55% GHG reduction also cuts the costs of controlling air pollution by more than €4.9 billion in 2030 for the whole EU. The reduction in mortality can also be assessed economically and the table shows that effective decarbonisation reduces premature deaths due to air pollution compared to the baseline. The largest part comes from PM_{2.5} reduction but there is also a reduction in premature mortality due to lower ground-level ozone levels. In 2030, the cost of health damage (based on mortality only) decreases by around €5 to 10 billion. Table 7 shows that effective stepping up of GHG reduction to 55% (MIX) in 2030 can reduce air pollution control cost by €4.9 billion and by €10 billion to 15 billion if both control costs and health damages are taken into account. In the ALLBNK scenario there is a significant

additional reductions in air pollution emissions. Premature mortality decreases significantly i.e. for ozone but also PM2.5, with monetised benefits amounting to between €14 billion and €22 billion.

Table 7: Impacts on air pollution and air pollution control costs in 2030 (EU27) of GHG reductions

	2015	BSL	MIX-50	MIX	ALLBNK	Relative to			
						2015	BSL		
						BSL	MIX-50	MIX	ALLBNK
SO ₂ emissions (1000t)	2473	935	874	776	737	-62.2%	-6.5%	-17.1%	-21.2%
NO _x emissions (1000t)	7037	3076	2959	2863	2820	-56.3%	-3.8%	-6.9%	-8.3%
PM2.5 emissions (1000t)	1364	721	738	694	696	-47.1%	2.3%	-3.8%	-3.6%
Air pollution reduction (%)(sum SO ₂ , NO _x , PM2.5)						-56.5%	-3.4%	-8.4%	-10.1%
Reduction in premature deaths PM2.5 (cases/year)						107062	-145	5020	7290
Reduction in premature deaths ozone (cases/year)						4888	111	254	648
ECONOMIC IMPLICATIONS									
Reduced air pollution control cost (€billion/year)(€ of 2015)						n/a	2.36	4.87	6.30
Reduced damage health PM2.5 (billion €/year)						107-214	0.15-0.29	5.02-10.04	7.29-14.58
Reduced damage health ozone (€billion/year)						4.89-9.78	0.11-0.22	0.25-0.51	0.65-1.30
SUM reduced control costs & damage savings (billion/year)						n/a	2.3	10.1-15.4	14.2-22.2

Note: Benefit valuation uses valuation of mortality used for the Climate and Energy package: 1 to 2 million 2015€ per premature death

Source: GAINS, 2015 data based on EEA (<https://www.eea.europa.eu/themes/air>, as of 24/07/2020)

The reduction in greenhouse gas emissions also reduce morbidity i.e. chronic bronchitis, hospital admissions, restricted activity days, medications use, days with lower respiratory symptoms and consultations for asthma and breathing problems. Reductions in air pollution therefore trigger potential for growth in economic activity through decreased absenteeism and increased worker productivity¹²⁹. In addition, damage to materials, crops and sensitive ecosystems (due to acidification, excess nitrogen deposition and ground level ozone) is reduced. Table 8 shows the reduction in ecosystem areas in the EU27 where acidification and eutrophication exceed critical loads that are harmful to ecosystems. The total ecosystem area where acidification exceeds critical loads decreases by 4.7 thousand km². The largest part of this is forest area. In addition, the area of ecosystems that exceeds critical loads for nitrogen in 2030 would be reduced by 8.7 thousand km².

In the MIX-50 scenario, by contrast, with a lower reduction of greenhouse gas emissions, we see that co-benefits for human health are negligible. However, air pollution control costs still drop by some 2.4 billion euro. Positive ecosystem impacts are just under half of those of MIX, when

¹²⁹ Dechezleprêtre, Antoine, Nicholas Rivers, and Balazs Stadler (2019): “The Economic Cost of Air Pollution: Evidence from Europe”, OECD Economics Department Working Papers No. 1584, 10 December 2019.

compared to baseline, with some 2.1 thousand km² of lower ecosystems affected by excess acidification and 3.7 thousand km² less by excess nitrogen loads.

Table 8: evolution of negative impacts (EU27) on sensitive ecosystems in 2030 compared to baseline

Ecosystem Impacts	Scenario			Difference to Baseline	
	Baseline	MIX-50	MIX	MIX-50	MIX
Acidification – Total Ecosystem area exceeded (1000 km ²)	56.0	53.9	51.2	-3.8%	-8.5%
Acidification - Forest area exceeded (1000 km ²)	43.5	41.6	39.3	-4.2%	-9.5%
Eutrophication - Ecosystems area exceeded (1000 km ²)	966.5	962.9	958.1	-0.4%	-0.9%

Source: GAINS model

6.3.2 Synergies and trade-offs of bio-energy use and land management in the context of increase climate ambition with biodiversity

Global warming and biodiversity loss are two interlinked issues that our societies need to address in an integrated manner. Climate change affects natural resources and ecosystems through droughts, flooding and wildfires, while the loss and unsustainable use of ecosystems are in turn drivers of climate change. The European Green Deal, and notably the EU climate action and the EU biodiversity strategy for 2030¹³⁰ aim at addressing these two threats by developing synergies between policies and ensuring that action taken on one side does not worsen the situation elsewhere.

Biodiversity loss is a complex matter¹³¹ to model. An attempt is made to look at impacts of EU land use change on species loss, using the Potentially Disappeared Fraction of global species indicator (see annex 9.5.1 for a detailed explanation including its inherent limitations and further information on the modelling results). The aim of this exercise was to compare the relative difference of impacts on species due to land use change by comparing BSL and MIX, the latter seeing increased bioenergy production in the EU albeit chiefly after 2030 (see also section 6.2.3).

Both in BSL and MIX the forest area in the EU increases by approximately 2 Mha a decade (in line with the roadmap announced in the EU Biodiversity Strategy), with in MIX even a bit more due to afforestation in view of increasing future supply of woody biomass but also a very limited increase in the share of forest under intensive management. Instead the more striking feature is the increase in production of energy crops on agriculture land for sustainable advanced biofuels and other types of bioenergy after 2030, mostly replacing cropland (including cropland currently used for conventional biofuels) and other natural lands¹³². Whereas biodiversity impact can be positive when replacing existing croplands, with woody biomass typically having less negative impacts on biodiversity, impacts are negative if replacing other natural land. Combined though impacts are projected to balance out.

¹³⁰ COM (2020) 380 final

¹³¹ IPBES, glossary, at: <https://ipbes.net/glossary/biodiversity-loss>

¹³² The other natural land category includes for instance non-productive grassland, agriculture land set aside, fallowed or abandoned and other type of vegetation not classified in other categories.

This result has to be interpreted with care.

While the analysis indicates that the production of the biomass needs projected in the MIX mitigation scenario could be achieved without detrimental impact on species loss, it is clear that only sustainable management of forests¹³³ and other land uses together with an overall reasonable deployment of energy crops would conciliate climate and biodiversity objectives.

The deployment of energy crops should neither increase the risk for an alien species to become invasive and cause damages to native ecosystems. The EU should produce its bioenergy feedstocks in accordance with the objective of the EU Biodiversity Strategy for 2030 to reduce by 50% the number of Red List species threatened by invasive alien species. This will require specific attention. Appropriate species selection and careful land use planning is required to address risks and possibly provide environmental benefits such as water filtration, ecosystem niches for insects and wild animals, protection against strong wind or soil carbon increase.

6.4 Economic impacts of achieving combination of GHG/RES/EE ambition levels

6.4.1 Energy system - economic impacts

6.4.1.1 Energy system costs

Energy system costs – capital and variable costs related to the use of energy – have been steadily increasing in recent years and are projected to grow. Table 9 shows the energy system costs (excluding carbon pricing payments and excluding disutility) in the different scenarios up to 2050.

Table 9: Average annual Energy System Costs (excluding carbon pricing payments and disutility costs¹³⁴)

Energy System Costs (€'15)* (excl. carbon pricing payments and disutility costs)		BSL	MIX-50	REG	MIX	MIX-nonCO2**	CPRICE	ALLBNK
in bn (average annual)	2021-'30	1,593	1,612	1,654	1,626	1,621	1,620	1,633
	2031-'50	1,774	1,915	1,922	1,926	1,923	1,913	1,919
% of GDP (average annual)	2021-'30	10.7%	10.9%	11.1%	11.0%	10.9%	10.9%	11.0%
	2031-'50	9.9%	10.7%	10.8%	10.8%	10.8%	10.7%	10.7%
in bn	2030	1,700	1,720	1,771	1,743	1,732	1,735	1,752
	2050	1,851	2,105	2,107	2,109	2,098	2,122	2,091
% of GDP	2030	10.9%	11.0%	11.3%	11.1%	11.1%	11.1%	11.2%
	2050	9.1%	10.4%	10.4%	10.4%	10.4%	10.5%	10.3%

Note: * Energy System Costs in 2015 are estimated at €1,340 billion (10.6% of GDP); ** MIX-nonCO2 is a variant of MIX looking at a stronger contribution of non-CO₂ emissions to the GHG reduction

Source: PRIMES model

¹³³ Including through afforestation policies that create diverse and resilient forests, restoration policies and deployment of energy crops that do not increase the risk for invasive alien species.

¹³⁴ Disutility costs measure the difference in the use of energy services compared to a counterfactual scenario using the income compensating variation method.

Energy system costs are projected to increase in BSL, reflecting the effort needed to meet the current climate and energy targets for 2030. The average annual energy system costs (excluding carbon pricing and disutilities) increase by 19% in the period 2021-2030 compared to 2015. Expressed as a share of GDP this increase is limited: from 10.6% in 2015 to 10.7% on average over the period 2021-2030. In the period 2031-2050, this share decreases to 9.9% of GDP on average.

The average annual additional costs (excluding carbon pricing and disutilities) in the policy scenarios vary across the scenarios, albeit not significantly. MIX-50, leading to less GHG reductions, has marginally lower cost than CPRICE, both projected at around 10.9% of GDP over the period 2021-2030. MIX and REG have slightly higher costs at 11.0% and 11.1% of GDP, respectively. ALLBNK, the highest ambition scenario, has costs higher than MIX but lower than REG. Comparing REG, MIX and CPRICE, costs are somewhat higher in REG due to higher investment needs linked to increased regulatory intervention (see section 6.4.1.3).

Comparing MIX-50, MIX and ALLBNK indicates that the higher the GHG reduction ambition by 2030, the higher the system costs, although overall differences are very limited. For the period 2031-2050 these relative differences even further reduce, with all scenarios showing costs around 10.7% and 10.8% of GDP, with CPRICE and MIX-50 having the lowest costs.

Overall the relatively limited mark-up of the policy scenarios over the BSL stems from significant GHG ambition of the latter which entails significant investments in energy efficiency, renewable energy deployment and shifts to low carbon technologies and fuels. This paves the way for easier access and reduced costs for energy-efficient and low-carbon technologies and fuels, due to scaling up and learning by doing effects, which help to reduce the additional energy costs for the policy scenarios. Reducing emissions to 55% by 2030 does not result in markedly higher system costs compared to lower ambition while resulting in a similar cost profile in the period after 2031-2050.

When disutility costs and carbon-related payments are included, the additional costs increase and the order reverses: in the period 2021-2030 REG's costs increase to 11.4% compared to GDP, while CPRICE increases further, to 11.6%. MIX is again very close to the case with lowest cost, i.e. the REG scenario when including disutility costs and carbon-related payments. Up to 2030, the MIX scenario thus stands as a middle solution to REG and CPRICE with positive characteristics of both policy approaches.

The differences in system costs including carbon pricing become more amplified in 2031-50 perspective with REG becoming the least cost scenario, lower than both MIX-50 and MIX, which display very similar costs.

Table 10: Energy System Costs (including carbon pricing payments and disutility costs)

Energy System Costs (€'15) (incl. carbon pricing payments and disutility costs)		BSL	MIX-50	REG*	MIX	MIX- nonCO2**	CPRICE	ALLBNK
2030 carbon price ETS sectors	2030	32	36	32	44	44	60	65
in bn (average annual)	2021-'30	1,614	1,677	1,693	1,698	1,692	1,715	1,734
	2031-'50	1,802	2,170	2,071	2,173	2,171	2,229	2,252
% of GDP (average annual)	2021-'30	10.9%	11.3%	11.4%	11.4%	11.4%	11.6%	11.7%
	2031-'50	10.1%	12.2%	11.6%	12.2%	12.2%	12.5%	12.6%
in bn	2030	1,721	1,804	1,828	1,840	1,827	1,866	1,891
% of GDP	2030	11.0%	11.5%	11.7%	11.8%	11.7%	11.9%	12.1%

Note: * REG scenario deploys other incentives and drivers than carbon pricing to achieve high RES and EE, therefore the carbon price does not increase compared to BSL (for more detail see annex 9.3.4); ** MIX-nonCO2 is a variant of MIX looking at a stronger contribution of non-CO₂ emissions to the GHG reduction

Source: PRIMES model

The MIX-nonCO₂ variant has lower costs than MIX because less efforts need to be undertaken in the energy sector. On the other hand the scenario does not assess in a similar manner the cost increase associated with more non-CO₂ mitigation efforts. The pattern is the same when looking at costs including carbon pricing and disutility costs.

Scenarios are most contrasted in the residential sector. In terms of capital costs, REG is the more expensive than CPRICE due to the specific investments it requires for renovations (see section 6.4.1.3). MIX is in-between. Conversely, energy purchases in REG are the lowest for residential and services, in line with lower energy demand, while for these two sectors CPRICE has the highest energy purchases costs. For more detail on sectoral system costs see annex 9.5.2.1 including on the evolution if the electricity prices.

6.4.1.2 ETS revenues, impact on public budgets

Carbon pricing increases energy costs to the consumer, but at the same time raises revenues which can be recycled, provide possibilities for reinvestments, stimulating climate action and providing resources to address social or distributional concerns.

The sources of income from carbon pricing depend on the policy instrument introducing carbon pricing. Taxation would ensure taxation and related revenues, but does not guarantee the environmental outcome. Emissions trading guarantees the environmental outcome through its cap but revenues are more variable and depend on the assumed free allocation of emission allowances¹³⁵.

¹³⁵ For the PRIMES-based modelling runs it has been assumed that industry in the ETS received free allocation (including the energy branch, process and non-CO₂ emissions) given that emissions reduce at a rate which seems close to what the benchmarks give as total allocation for the period 2021-2030 (see Section 6.9). Most other sectors pay the full carbon price. Furthermore in MIX and REG there is a revision foreseen in transport related to the Energy Taxation Directive, with an alignment of minima on energy content for diesel and petrol in both scenarios, while REG additionally foresees the mirroring of the ratio on the national level.

Table 11: Carbon pricing payments and energy taxes across scenarios

		BSL	MIX-50	REG	MIX	MIX-nonCO2*	CPRICE	ALLBNK
Carbon Price in €/tCO ₂	2030	32	36	32	44	44	60	65
Carbon pricing payments in bn €'15 (average annual)	2021-'30	18	43	18	46	47	62	66
	2031-'50	22	92	32	87	87	132	134
Carbon pricing payments in bn €'15	2030	16.0	49.8	15.5	54.9	55.8	75.4	81.6
Residential	2030	0.0	4.8	0.0	5.2	5.2	7.2	7.1
Tertiary		0.0	2.3	0.0	2.7	2.7	3.5	3.7
Transport		0.7	28.4	5.9	34.1	34.1	46.9	55.3
Power generation		14.9	13.9	9.6	12.7	13.6	17.5	15.3
District heating		0.4	0.3	0.1	0.2	0.2	0.2	0.1
Share of carbon pricing payments in energy system costs	2030	0.9%	2.8%	0.9%	3.1%	3.1%	4.2%	4.4%
Total energy taxes (excise taxes and VAT) in bn €'15	2030	269	271	281	270	269	277	273
Share of energy taxes in energy system costs	2030	15.7%	15.3%	15.7%	15.0%	15.1%	15.3%	14.9%
Total share of energy taxes and carbon payments in energy system costs	2030	16.6%	18.2%	16.6%	18.1%	18.2%	19.5%	19.3%

Note: *MIX-nonCO2 is a variant of MIX looking at a stronger contribution of non-CO₂ emissions to the GHG reduction

Source: PRIMES model

It can be noticed that the energy tax income in the policy scenarios is comparable to BSL, in spite of lower energy consumption than in BSL. The main reason for that is that we see a shift away from energy carriers that have relative low taxation levels, such as coal, towards energy carriers that have a higher taxation content.

The variation is much more pronounced for the carbon-related payments which are twice as large in CPRICE as in REG, raising in CPRICE €75 billion in 2030 due to the higher carbon price and the extension of carbon pricing to road transport and buildings. These payments, or budgetary revenues, remain smaller than the total energy taxes paid for fuel consumption, which range between €269-281 billion across scenarios.

While in the baseline energy taxes and carbon prices in 2030 raise revenue equivalent to 1.8% of GDP, in CPRICE this increases to 2.25%. The extension of carbon pricing to a wider range of sectors of the economy should therefore not be seen as a game-changer in terms of the structure of public finances. Section 6.4.2 points out, however, that carbon pricing – and by extension taxes on environmental externalities – offers an opportunity for a double dividend: climate and environmental benefits, coupled with a reduction in distortionary taxes and improved allocative efficiency leading to higher output. The scale of the potential tax shift (and double dividend) depends to a large extent on the scope of carbon pricing as well as on the level of the carbon price itself. In addition, carbon revenues are inherently transitory and the more effective carbon pricing is, the faster the revenue base is set to erode and substituting sources of public revenue are to be found.

6.4.1.3 Investment challenge

The achievement of the current 2030 targets projected in BSL would require in the period 2021-30 energy system investments (excl. transport) of on average EUR 336 billion per annum (constant prices of 2015), equivalent to 2.3% of GDP¹³⁶. In 2031-50 perspective, investment needs decrease to, on average, some EUR 280 billion per annum (1.6% of GDP) as no additional policies are implemented.

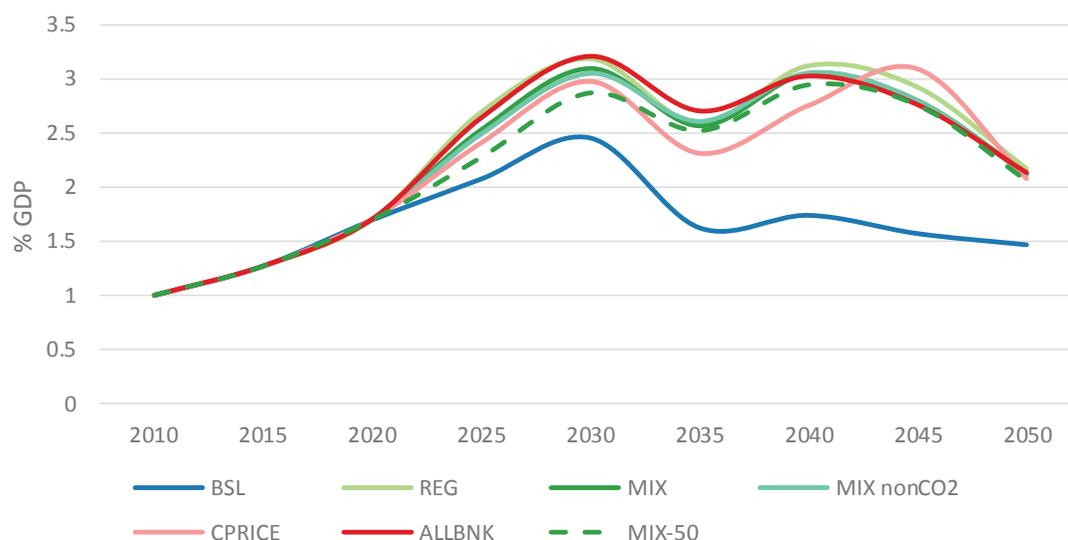
The modelling shows a strong correlation between increased climate ambition and increased energy system investment needs and indicates that investment intensities vary according to the policy architecture chosen for a given level of GHG reduction ambition. While MIX-50 increases average annual energy system investment needs (excl. transport) in 2021-2030 by EUR 39 billion compared to BSL, 55% GHG policy scenarios increase them between EUR 65 billion to EUR 102 billion (scenario ALLBNK is within this range). Different policy architectures assumed in CPRICE, MIX and REG also lead to slightly different technology pathways, which has an impact on investment needs. This corroborates earlier findings in the in-depth analysis accompanying Clean Planet for All Communication.

Figure 11 shows that as a share of GDP, the average annual investments (excl. transport) in the period 2021-30 would need to rise from 2.3% in BSL to 2.5% in MIX-50) and between 2.7% (CPRICE) and 3.0% (REG). Compared to the period 2011-2020, and including transport, this represent an increase in annual investments of EUR 263 billion in BSL, EUR 312 billion in MIX-50 and respectively EUR 326, 356 and 377 billion in CPRICE, MIX and REG. As a share of GDP, this is an increase equivalent to 1.5, 1.7 and 1.8 percentage points of GDP in the period 2021-2030 compared to the period 2011-2020. While this is a significant increment, it needs to be put in the perspective of the share of gross fixed capital formation in GDP in the EU, which amounted to about 21.5% on average in 2000-2019.

Importantly, BSL already integrates the significant targets of the 2030 climate and energy framework. Achieving these targets would in itself represent a higher level of energy system investment as a share of GDP than has been the case over the past decade. Looking towards the 2050 horizon and the climate neutrality objective, it is also evident that investment in the energy system would need to be sustained for a long period at a higher level relative to GDP than has been the case so far.

¹³⁶ This is about EUR 15 billion lower than estimated previously for the Clean Planet for All Communication, also using the PRIMES model and a comparable methodology, on account of lower technological costs. The investment needs to achieve the current 2030 climate and energy framework were evaluated in the associated impact assessment. Similarly, the in-depth analysis in support of Commission Communication “A Clean Planet for all” included updated estimates of such investment needs. Neither of these estimates, however, can be used for the investment needs that derive from raising climate ambition in the 2030 horizon. First, previously published numbers include the United Kingdom in the aggregate estimates. Second, those numbers are based on technology costs assumptions that differ from the current ones. Third, the investment needs estimates of the 2030 climate and energy framework impact assessment were based on lower energy efficiency and renewables targets than those ultimately adopted.

Figure 11: Energy system investment, excluding transport, 55% scenarios and MIX-50 (% GDP)



Source: PRIMES model

At EUR 438 billion in 2021-2030, average annual energy system investments needs (excluding transport) to achieve the 55% level of ambition are EUR 37 billion higher under REG than under CPRICE (EUR 401 billion), while MIX and its MIX-nonCO2 variant fall between these two scenarios. This is mostly due to higher buildings renovations that are incentivised by policies but not much so by the carbon price signal. The difference between REG and CPRICE remains significant when considering cumulative investment needs over the period 2021-2050 to achieve climate neutrality by 2050, though somewhat smaller at EUR 28 billion per annum¹³⁷. Additional mitigation efforts on the supply and demand sides due to the inclusion of bunker fuels in the GHG target imply an increase in energy system investment under ALLBNK, but the annual average remains slightly lower than under REG both in 2021-2030 and 2031-2050 perspective. Table 12 shows the complete picture of additional investments needs of all policy scenario and MIX-nonCO2 variant as compared to BSL. The differences in investments needs across energy system sectors are discussed in annex 9.5.2.2.

¹³⁷ This difference is persistent even though the scenarios share the same technology costs assumptions and all available technologies (e.g. renewables, energy efficiency in buildings and production processes or decarbonisation of transport) will need a strong degree of deployment in order to reach a high level of climate ambition by 2030 and climate neutrality by 2050.

Table 12: Additional annual investment compared to BSL for all policy scenarios and MIX-nonCO2 variant (2021-2030 and 2031-2050, billion euros 2015)

	MIX-50			REG			MIX			MIX-nonCO2			CPRICE			ALLBNK		
	Average 2021- 2030	Average 2031- 2050	Average	Average 2021- 2030	Average 2031- 2050	Average	Average 2021- 2030	Average 2031- 2050	Average	Average 2021- 2030	Average 2031- 2050	Average 2021- 2030	Average 2031- 2050	Average 2021- 2030	Average 2031- 2050	Average 2021- 2030	Average 2031- 2050	
Investments in power grid	2.2	33.3	32.2	7.7	30.2	30.2	6.5	31.1	7.8	31.7	9.6	29.6						
Investments in power plants	6.0	68.0	59.0	14.4	62.1	62.1	11.9	63.3	13.5	65.6	17.5	59.0						
Investments in boilers	1.4	-0.4	-0.8	1.8	-0.7	-0.7	1.6	-0.7	2.1	-0.4	2.6	-0.6						
Investments in new fuels production and distribution	0.9	27.1	24.1	1.3	26.1	26.1	1.2	25.8	1.2	27.7	2.0	25.3						
<u>Total supply side investments</u>	<u>10.5</u>	<u>128.0</u>	<u>114.6</u>	<u>25.2</u>	<u>117.6</u>	<u>117.6</u>	<u>21.3</u>	<u>119.4</u>	<u>24.5</u>	<u>124.6</u>	<u>31.8</u>	<u>113.3</u>						
Industrial sector investments	2.5	4.7	6.0	3.4	4.4	4.4	3.3	4.3	3.6	3.4	5.0	4.8						
Residential sector investments	15.4	19.6	55.2	38.8	37.2	37.2	38.0	37.6	21.1	16.6	41.9	39.0						
Tertiary sector investments	10.2	24.5	20.5	14.5	23.8	23.8	14.1	24.2	16.1	28.1	19.6	29.1						
Transport sector investments	10.2	29.4	38.8	11.3	31.2	31.2	11.5	31.4	-2.5	33.3	9.8	29.0						
<u>Total demand side investments</u>	<u>38.3</u>	<u>78.2</u>	<u>120.5</u>	<u>68.0</u>	<u>96.6</u>	<u>96.6</u>	<u>67.0</u>	<u>97.5</u>	<u>38.4</u>	<u>81.4</u>	<u>76.4</u>	<u>101.9</u>						
<u>Total demand side investments excl. transport</u>	<u>28.0</u>	<u>48.8</u>	<u>81.7</u>	<u>56.7</u>	<u>65.4</u>	<u>65.4</u>	<u>55.5</u>	<u>66.1</u>	<u>40.9</u>	<u>48.0</u>	<u>66.6</u>	<u>72.9</u>						
Total energy system investments	48.8	206.2	235.0	93.2	214.2	214.2	88.3	216.9	62.9	206.0	108.2	215.2						
Total energy system investments excl. transport	38.5	176.8	196.3	81.8	183.0	183.0	76.7	185.5	65.4	172.6	98.3	186.2						

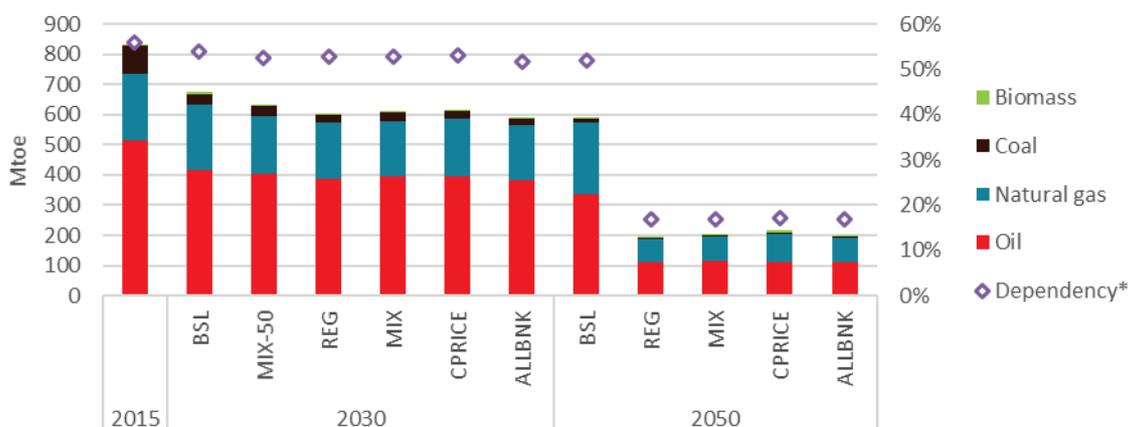
Source: PRIMES model

6.4.1.4 Implications for security of energy supply

Imports of fossil fuels¹³⁸ are projected to decrease over time and this trend is strengthened with the higher GHG reduction ambition (Figure 12). Already in BSL, the volume of fossil fuels imports decreases by 19% between 2015 and 2030. On average under the 55% scenarios, the volume of fossil fuel imports falls by 27% over the same period, with coal down by 71-77%, natural gas by 13-19% and oil by 23-25%¹³⁹, depending on the scenario. Reductions would be less pronounced in MIX-50 scenario. As a consequence, in the policy scenarios the dependency ratio goes down in 2030 to 52-53% (slightly lower in REG compared to MIX and CPRICE), versus 54% in BSL and 56% in 2015.

Beyond 2030, fossil fuel imports shrink dramatically, virtually disappearing for coal, decreasing by 58-67% for natural gas and 78-79% for oil compared to 2015.¹⁴⁰

Figure 12: Energy imports



Note: * Dependency is the ratio between total net imports and gross available energy (gross inland consumption and maritime bunkers)

Source: 2015: Eurostat, 2030-2050: PRIMES model

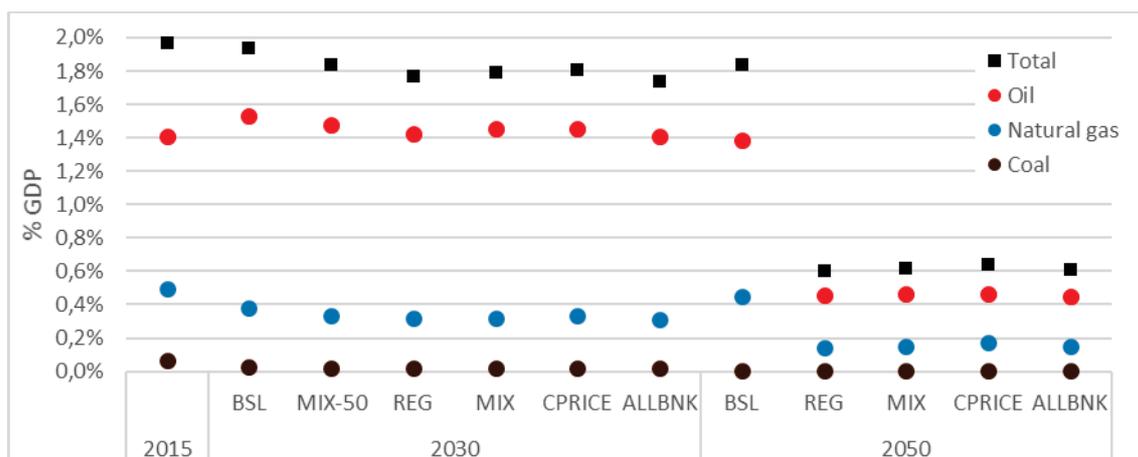
As a consequence, the cost of energy imports compared to GDP also decreases although more slowly than volumes, due to assumed increasing international fossil fuel prices over the period. From 2% of GDP in the BSL in 2030, it would go down to 1.8% in the policy scenarios and 0.6% in 2050. In 2030, this would mean that savings from reduced energy imports could reach between 0.1 and 0.2% of GDP with higher benefits linked to increased climate ambition and more pronounced energy savings. Compared to BSL, cumulative savings in net energy imports in 2021-2030 range between EUR 83 billion and EUR 133 billion in the 55% scenarios and amount to EUR 69 billion in MIX-50. Over the period 2021-2050 and achieving climate neutrality by 2050, the 55% scenarios reduce energy imports by up to EUR 3 trillion compared to BSL.

¹³⁸ Total imports include biomass, which remains marginal: 3 Mtoe in 2015, 3-6 Mtoe in the different scenarios analysed.

¹³⁹ The imports of oil also account for demand for international maritime bunkers, which are not accounted for in the gross inland consumption discussion in section 6.2.1.2.

¹⁴⁰ The Wiener Stadtwerke GmbH also perceives a lack of importance of the role of renewable gas in security of supply.

Figure 13: Cost of energy imports (% of GDP)



Source: Energy: 2015: Eurostat, 2030-2050: PRIMES model; fuel prices assumptions: see annex 9.3.2

Because further GHG reductions will affect the way electricity is produced, it will also have implication in terms of security of electricity supply. In a context of decreasing flexible sources of electricity generation due to coal phase-out and nuclear retirement¹⁴¹, which will require close monitoring and coordination, the growing contribution of variable renewables in the power production will need to be met by new flexibility means along the whole electricity supply chain.

Storage solutions complemented in time with electrolysers and more flexible demand (notably in relation with the higher penetration of electric vehicles which are expected to provide flexibility to the electricity system) will play a key role to integrate the different components of the energy system, allowing for a full decarbonisation and the full deployment of, notably, renewable primary energy sources.

Finally, the EU power system while growing and becoming increasingly important for the EU economy due to electrification of the final demand, will also become increasingly decentralised, interconnected and relying on digitalisation. More broadly, the integration of the energy system by the linkage of multiple energy carriers, infrastructures, and consumption sectors, will further increase the level of complexity as discussed in the EU Strategy for Energy System Integration¹⁴². In this context, addressing cybersecurity will be of utmost importance to guarantee continuity of economic and social services and mitigate risks on critical infrastructures.

Security of energy supply will thus have to be addressed in a holistic manner, also considering new possible dependencies on and cross-sectoral competition for raw materials necessary for the deployment of new technologies and on the role that new fuels will progressively play. The Communication^{143,144} on “Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability” lays the ground for a secure and sustainable supply of critical raw materials and actions to increase EU resilience and strategic autonomy.

¹⁴¹ See IEA (2020), Energy Policy Review, European Union 2020.

¹⁴² COM(2020) 299

¹⁴³ COM(2020) 474 final

¹⁴⁴ https://ec.europa.eu/commission/presscorner/detail/en/ip_20_1542

6.4.2 Macro-economic impacts (GDP, competitiveness)

Climate and energy policy have wide-ranging implications on the economy, including in terms of the sectoral composition of demand, output and employment, relative producer and consumer prices and the international competitiveness of domestic firms. The transition to climate neutral economies requires innovation and the reallocation of productive capital and the labour force across and within sectors. This is a gradual process that entails shifts in investment patterns. This in turn creates risks related to the retirement of productive assets before the end of their economic lifetime and potentially difficult adjustments in the labour market as a result of natural frictions and potential mismatches between skills available and the skills requirements of the economy. The speed at which the process transition has to take place increases the challenges related to resource reallocation. As the COVID-19 pandemic has made amply evident, however, many other factors affect the economy in multiple and at times significant manners, whether in terms of cyclical developments or structural changes.

The baseline macro-economic projections for this Impact Assessment are based on DG ECFIN's autumn 2019 forecast and therefore pre-date the COVID crisis¹⁴⁵. Three modelling tools sharing this common baseline are used to assess the macro-economic impacts of the increased level of climate ambition for 2030: the Joint Research Centre's JRC-GEM-E3, Cambridge Econometrics' E3ME and DG ECFIN's E-QUEST. These tools are underpinned by different modelling approaches and their use can therefore enrich the analysis and validate key findings. Annex 9.3.1.2 provides a description of the models.

Macro-economic impacts are assessed under a number of scenarios and variants. Given the critical role of economic interactions with the rest of the world, in particular regarding exports and the domestic output of sectors open to international trade and competition, two levels of climate ambition are considered for countries or blocks outside the EU: (1) implementation of Nationally Determined Contributions under the Paris Agreement ("fragmented action"); and (2) mitigation efforts that are compatible with the achievement of the 1.5°C target ("global action").

The modelling variants performed with the different macro-economic modelling tools seek to assess the impact of using different economic tools to achieve climate and energy objectives. These variants address:

- The extent to which carbon pricing/emissions trading with auctioning is used across sectors as a policy tool to reduce emissions
- How carbon revenues are used by governments, with several options used in various models: (1) lump sum redistribution to households; (2) a reduction in labour taxation; (3) support for investments towards the climate and energy transition; and (4) a reduction in VAT rates;
- The role of labour market imperfections;

¹⁴⁵ DG ECFIN's autumn 2019 forecast projects cumulative real GDP growth of 24.2% over the period 2015-2030. In contrast, the spring 2020 forecast that was used for the COVID sensitivity analysis in this impact assessment predicts a contraction in EU real GDP of 7.4% in 2020 followed by a 6.1% recovery in 2021. Potential output growth projections were also revised downwards slightly, which implies that cumulative real GDP growth over the period 2015-2030 amounts to 21.3%, leaving EU real GDP 2.3% below the pre-COVID projections in 2030. DG ECFIN's summer 2020 forecast were slightly more pessimistic still, with a projected contraction in EU real GDP of 8.3% in 2020 and a recovery of 5.8% in 2021. See section 6.4.3 for the discussion on the COVID crisis impacts.

- The behaviour of energy-intensive industries in the EU ETS which are open to international trade when confronted with free allocation or auctioning.

In addition, JRC-GEM-E3 was used to assess the link between the three main energy system modelling scenarios (REG, MIX and CPRICE) and the macro-economic impacts. As a rule in the results below, exogenous assumptions fed into JRC-GEM-E3 are those from the MIX scenario.

The impact of climate and energy policy on real GDP is projected to be relatively muted and could range from somewhat positive to somewhat negative, depending on the modelling approach used and the variants considered in terms of policy action (Table 13). The policy and modelling variants differ across models, but convey a consistent message: the type of policies put in place to achieve increased GHG reductions are important factors for the overall impact on GDP. Economy-wide impacts are smallest if policies are applied that put a price on the externality the policy wants to address and reduce distortionary taxes in other fields, e.g. in terms of labour taxation.

Table 13: Impact of policies and modelling assumptions on GDP to achieve 55% GHG reductions in case of fragmented action at the global scale (deviation from baseline, percent)

<u>Policy setup</u>	- Lump sum transfers - Imperfect labour market - Free allocation ETS - Scope extension ETS - No carbon pricing non-ETS	- Tax recycling - Imperfect labour market - Free allocation ETS - Scope extension ETS - No carbon pricing non-ETS	- Tax recycling - Imperfect labour market - Free allocation ETS - Scope extension ETS - Carbon pricing non-ETS
JRC-GEM-E3*	-0.39	-0.27	-0.27
<u>Policy setup</u>	- Lump sum transfers - Free allocation ETS - No carbon pricing non-ETS	- Tax recycling - Free allocation ETS - Carbon pricing non-ETS	- Tax recycling - Auctioning ETS - Carbon pricing non-ETS
E3ME	0.19	0.42	0.50
<u>Policy setup</u>	Lump sum transfers	Lower taxation low-skilled labour	Support green invest.
E-QUEST	-0.29	0.00	0.13
* All JRC-GEM-E3 scenarios assume free allocation in ETS industry and auctioning in the power sector (as well as buildings and road transport in case of scope extension ETS). For industrial sectors it is assumed companies cannot incorporate the opportunity cost of free allocation and thus optimise market share.			

Source: JRC (JRC-GEM-E3 model), Cambridge Econometrics and DG ECFIN

Table 14 gives an overview of the range of outcomes for the three models and various scenarios and their policy variants. The worst-case scenario under a setting where the EU achieves a 55% level of GHG ambition and the rest of the world does not step up ambition relative to NDCs implies a loss of GDP of about 0.4% by 2030 (JRC-GEM-E3). At best, achieving this level of ambition in the EU without global climate action would generate an increase in GDP of about 0.5% (E3ME), which would result from a demand stimulus triggered by higher investment needs and the impetus given to consumption by the use of carbon revenues to reduce VAT and support energy efficiency investments. Results from E-QUEST indicate that the GDP impact of a 55% level of ambition could be somewhat positive at around 0.1% by 2030, if carbon revenue are used to support investment in green technologies, and somewhat negative (-0.3%) if revenues are

returned to households via lump sum transfers. The impact of a 50% level of ambition are of a similar nature, though somewhat muted both on the negative and positive sides.

Table 14: Impacts of 50% and 55% reduction on EU GDP and components (deviation from baseline, percent)

EU GDP vs. baseline, 2030 (range of impacts due to increased EU GHG ambition across scenarios with diversified policy setups).				
	50%		55%	
	<u>Fragmented action</u>	<u>Global action</u>	<u>Fragmented action</u>	<u>Global action</u>
JRC-GEM-E3				
Real GDP	-0.13 -0.02	-0.38 -0.25	-0.39 -0.25	-0.70 -0.47
Private consumption	-0.38 -0.16	-2.14 -1.62	-0.71 -0.38	-2.53 -1.87
Investment	0.79 0.85	0.76 0.81	0.52 0.57	0.41 0.48
Exports	-0.80 -0.09	1.43 2.32	-0.96 -0.28	1.21 2.11
Imports	-0.34 -0.06	-1.91 -1.15	-0.55 -0.25	-2.14 -1.36
E3ME				
Real GDP	0.13 0.41	0.12 0.42	0.18 0.50	0.22 0.55
Private consumption	0.00 0.52	0.11 0.66	0.07 0.65	0.22 0.82
Investment	0.21 0.25	0.24 0.29	0.18 0.25	0.25 0.31
Exports	0.03 0.06	-0.08 -0.06	0.01 0.06	-0.08 -0.05
Imports	-0.25 -0.17	-0.16 -0.08	-0.39 -0.29	-0.29 -0.20
QUEST				
Real GDP	n.a	n.a.	-0.29 0.13	n.a.
Private consumption	n.a	n.a	-0.07 0.09	n.a
Investment	n.a	n.a	-0.55 0.62	n.a
Exports	n.a	n.a	-1.36 -0.55	n.a
Imports	n.a	n.a	-1.01 -0.52	n.a

Sources: JRC-GEM-E3, Cambridge Econometrics, DG ECFIN and JRC-POLES

Under a setting where the EU achieves a 55% level of GHG ambition and the rest of the world also increases ambition in line with the 1.5°C objective, the JRC-GEM-E3 projects a somewhat larger negative impact on real GDP due to the repercussions of a loss of output outside the EU. In addition, the output of energy intensive industries tends to increase relative to baseline under global action on account of their higher average carbon efficiency than in the rest of the world (see below). This moderate increase in output in energy intensive sectors means that more abatement investments are required within these industries or in other parts of the ETS in order to remain within cap, which comes at a cost. In contrast, global action provides a further impetus to growth in the E3ME model set up, as increased investment in the rest of the world generates a global demand stimulus with positive repercussion for the EU.

These contrasted outcomes reflect a core difference in the economic assumptions underpinning the models. JRC-GEM-E3 assumes that the economy operates in equilibrium without spare capacity while E3ME assumes that economy has some unused resources to begin with and that debt-finance can fund additional expenditure without full crowding out. Under current circumstances, where a major potential output gap has opened in the EU economy due to the

COVID-19 crisis and where large stimulus packages are programmed, it is realistic to assume that the economy has spare capacity. However, projections from JRC-GEM-E3 and E3ME tend to converge in the longer term as the stimulus generated by higher investment under E3ME tapers off and the associated borrowing needs to be repaid.

The macro-economic impacts of extending carbon pricing to road transport and buildings were assessed with JRC-GEM-E3, linking up with the MIX, REG and CPRICE energy system scenarios. The carbon pricing extension leads to a sharp increase (up to six fold depending on the model setup) in carbon revenues. In the JRC-GEM-E3 assessment, these revenues are either transferred back to households as lump-sum payments or recycled to lower labour taxation. Given the scale of the increase in carbon revenue, the recycling option clearly matters more under scope extension than without it. Table 15 shows that where carbon revenues are used to reduce labour taxation and labour market imperfections are factored in, MIX and CPRICE (scope extension) generate a smaller negative impact on GDP by 2030 than REG. Where carbon revenues are transferred back to households as lump sums, the impact on GDP is equivalent under the three scenarios.

Table 15 also indicates that private consumption is somewhat more negatively affected under scope extension, which implies a more significant expenditure shift towards investment. As far as employment is concerned, the increase in carbon revenue following scope extension is susceptible to generate positive impacts under a recycling policy. Finally, it must also be noted that REG, MIX and CPRICE affect relative prices in the economy in contrasted manners, with MIX and CPRICE significantly impacting fuels and power prices faced by households, while REG has a more significant impact on the cost of housing and water charges.

Table 15: Macro-economic impacts of carbon pricing extension (REG, MIX and CPRICE), 55% fragmentation action scenarios, deviation from baseline, percent)

EU impacts on key variables vs. baseline, 2030						
	- Tax recycling - Imperfect labour market - Free allocation ETS - Market share maximisation ETS			- Lump sum transfers - No labour market imperfections - Free allocation ETS - Profit maximisation ETS		
	REG	MIX	CPRICE	REG	MIX	CPRICE
Real GDP	-0.30	-0.27	-0.24	-0.23	-0.25	-0.25
Private consumption	-0.53	-0.71	-0.79	-0.41	-0.46	-0.44
Investment	0.49	0.57	0.86	0.50	0.56	0.83
Employment	-0.09	0.06	0.15	0.00	0.00	0.00
“Fuels and power” prices	-1.62	4.55	9.96	-1.92	3.47	8.07
“Housing and water charges” prices	2.67	1.77	0.14	2.68	1.82	0.19

Source: JRC-GEM-E3 model

The consistent conclusion that emerges from macro-economic analyses is therefore that the reallocation of resources necessary for the transition can be seen as a modest contributor to GDP growth, or at worst a limited impediment. It must be noted that this analysis does not assess the sustainability of the growth model, but focuses on the specific real GDP metric without taking due account of the externalities the policy is actually addressing and its associated co-benefits.

Importantly, the analysis also focuses on the impact of mitigation efforts and does not take into account avoided climate impacts.

Further, the combination of macro-economic and energy system models show that the GHG intensity of the EU economy can be sharply reduced over the next decade, with GHG emissions per unit of real GDP falling by 52.0% between 2015 and 2030 under MIX, compared with 48.4% under MIX-50 and 44.7% under BSL¹⁴⁶.

The models also converge on the finding that the composition of GDP will be affected more significantly than the aggregate itself, including in terms of expenditure and sectoral gross value added. Achieving higher climate and energy ambition would require a reallocation of expenditure from consumption to investment under the JRC-GEM-E3 model. While a fall in private consumption has implications in terms of welfare, the main category of consumer goods to be negatively affected is the consumption of non-durables linked to durable goods (mainly energy costs). E3ME also indicates a positive impact on investment, but the increase does not come at the expense of a reduction in private consumption as the model assumes that the economy has some unused resources to begin with and that borrowing can fund additional investment without crowding out consumption. E-QUEST generates a smaller impact on total investment as the negative impact on capital expenditure related to fossil fuels use is significant and counterbalances the increase in “green” capital formation.

The modelling tools used for macro-economic analysis do not provide direct insights on specific outcomes for SMEs. However, the macroeconomic analysis indicates a favourable outlook for such companies: a European economy that becomes more capital and technology intensive and increasingly based on the development of innovative products and solutions. Conversely, no trend was identified that would harm specifically SMEs, considering that they are typically not particularly active in carbon intensive sectors.

Besides the impact on the overall consumption level, a higher level of climate ambition will affect relative prices in the economy. As expected and following developments in energy system costs (section 6.4.1.1), the relative price of fuels and power is to be impacted most. The relative prices of the use of private vehicles and transport services are also set to increase relative to baseline, though to a lesser extent. The implications of such changes in relative prices on distributional impacts due to differentiated consumption patterns are assessed in section 6.5.2.

The higher level of mitigation ambition will also affect sectoral investment significantly. As expected, investment in fossil fuels would drop sharply, in particular for coal. Similarly, the transition to clean power technologies and the electrification of the economy would imply a significant increase in investment in electricity supply. In industrial sectors, investment is affected by two contrasting trends: the need to invest for decarbonisation purposes and the evolution of output in the sector. While the first trend generates a clear positive effect on investment needs, the second varies across scenarios and setups. Global action tends to generate a positive impact on the sectoral output of energy intensive industries (see below), implying an overall positive effect on investment. In contrast, fragmented action tends to generate a negative impact on the sectoral output of energy intensive industries, with the effect of lower investment needs for new/refurbished productive capacity outweighing the impact of higher investment for decarbonisation.

¹⁴⁶ Based on the GHG scope including domestic and intra-EU emissions from aviation and navigation.

The sectoral composition of output is also set to be impacted in significant and contrasting ways. As expected, output in fossil-fuel sectors would drop severely, starting with coal. Output of the major energy-intensive and internationally traded goods is expected to be affected most under a fragmented action setting, though the negative impact is moderate both under the 50% and 55% levels of GHG ambition for 2030 (Table 16), with at most a decline of 2.4% in gross value added in non-ferrous metals in 2030 relative to baseline. The higher the openness to trade of the sector and the carbon intensity, the larger the impact tends to be. Chemicals products and paper products are therefore less impacted than ferrous metals, non-ferrous metals and non-metallic minerals, under a fragmented action setting.

Table 16: impacts of 50% and 55% reduction on EU sectoral output (deviation from baseline, percent)

Sectoral output vs. baseline, 2030 (range of impacts due to increased EU GHG ambition across scenarios with diversified policy setups).				
	50%		55%	
	<u>Fragmented action</u>	<u>Global action</u>	<u>Fragmented action</u>	<u>Global action</u>
Coal	-18.1 -16.7	-16.2 -14.6	-41.4 -40.6	-39.5 -38.6
Crude Oil	-5.9 -3.8	-7.2 -5.6	-6.5 -4.3	-7.9 -6.1
Oil	-5.0 -3.4	-7.5 -5.7	-5.7 -4.0	-8.5 -6.4
Gas	-14.5 -11.4	-9.6 -7.8	-15.3 -12	-10.5 -8.4
Electricity supply	0.2 0.6	3.7 4.3	-1.9 -1.6	1.1 1.8
Ferrous metals	-3.2 0.1	3.4 7.1	-4.0 -0.6	2.2 6.3
Non-ferrous metals	-1.7 0.1	4.2 6.5	-2.7 -0.8	3.0 5.4
Chemical products	-0.7 0.0	0.7 1.4	-0.9 -0.3	0.4 1.0
Paper products	-0.3 -0.1	0.3 0.5	-0.6 -0.4	-0.1 0.1
Non-metallic minerals	-1.5 0.3	1.2 3.3	-2.1 -0.1	0.4 2.7
Electric goods	0.5 1.3	3.3 4.2	-0.1 0.7	2.6 3.6
Transport (air)	-4.2 -0.2	-4.5 0.3	-4.8 -0.4	-5.5 0.1
Transport (land)	-1.2 -1.0	-1.3 -1.0	-1.5 -1.2	-1.7 -1.2
Transport (water)	-0.4 -0.2	-3.8 -3.3	-0.6 -0.3	-3.9 -3.4
Construction	0.8 0.8	0.6 0.7	0.4 0.4	0.1 0.2
Market services	-0.2 0.0	-1.1 -0.9	-0.3 -0.1	-1.3 -0.9

Source: JRC-GEM-E3 model

If the rest of the world steps up climate action to mitigation efforts in line with the 1.5°C objective (compared with NDCs implementation under the baseline), output of energy intensive industries in the EU is much less affected relative to baseline. This indicates that EU industry could benefit from first-mover advantages. While the international context plays an important role in developments in energy intensive sectors, domestic factors and policies are also key driving factors, in particular the free allocation of ETS allowances and the use of carbon revenues by the authorities (see annex 9.5.3 for further details).

Macroeconomic impacts will also vary between Member States. All European economies are expected to follow similar trajectories becoming more capital and technology intensive and increasing shares of the service sector. However, not all Member States are at the same point of departure on this overall trajectory. More ambitious climate targets are likely to come at a relatively higher costs for Member States characterised by higher relative GHG emissions, higher energy intensity and lower GDP per capita. Some higher income Member States also face

particular issues of higher relative costs, for instance, due to the size of certain sectors, such as non-CO₂, forestry or the state of the buildings sector and its energy mix.

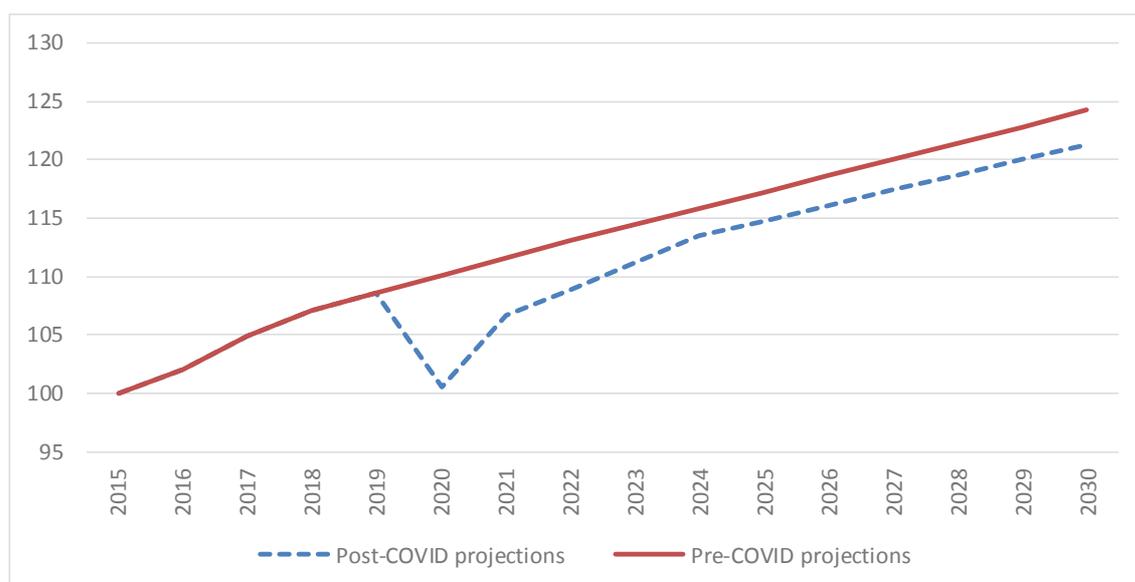
Overall, the following conclusions can be drawn. First, a higher level of climate ambition for 2030 is expected to have only limited impacts on broad economic aggregates. Modelling tools that take into account that there may be an output gap, which is the more likely case for the EU economy in the context of the COVID-19 crisis, show positive growth impacts of increased climate ambition. Second, the analysis stresses that impacts can indeed be significant in terms of sectoral output, investment and employment (section 6.5.1). This creates challenges for the management of the transition, including to ensure that the needs of sectors, households and workers most affected are addressed. Third, while macro-economic models provide significant insights on the shifting composition of output, they offer little detail of the necessary within-sector transformations.

Finally, macro-economic models are not in a good position to address issues related to the “quality of growth”, which are central to the European Green Deal. Real GDP and sectoral gross value added are just a metric of production that does not factor in the quality of the environment we live in, biodiversity and many other aspects of welfare. These concerns are nevertheless at the core of the Green Deal, which places fairness, resource efficiency, sustainability and the achievement of the United Nations’ Sustainable Development Goals at its heart.

6.4.3 *The COVID-19 crisis and how to ensure a swift green recovery*

The impact of the COVID-19 crisis is uncertain. For a more in-depth discussion of how the unfolding crisis is impacting notably the economic outlook, the energy sector and overall GHG emissions, see annex 9.10.1.3. For this Impact Assessment an evaluation was made how reduced economic growth and moderate additional structural change may impact the transition in the energy system and the related investments needed. While the short-term forecast points to a sharp drop in output in 2020 followed by significant recovery in 2021, the crisis is projected in this setting to result in a permanent loss of output of around 2.3% by 2030 compared to the pre-COVID projections (Figure 14).

Figure 14: *Medium-term EU real GDP projections, pre-COVID and post-COVID (2015=100)*



Looking to 2030, the projections take a conservative approach regarding the potential structural shifts described in annex 9.10.1.3, given the uncertainty that surrounds them. It is estimated that the economic impact of the COVID crisis in 2020 could lead to an additional 6 percentage points reduction in GHG emissions (excluding net LULUCF, including domestic and international aviation) resulting in a reduction by 2020 of -32%.

Table 17: Projected impact of COVID on key climate and energy variables in 2020 (COVID-BSL vs. BSL, percent difference)

Projected 2020 impact in COVID-BSL compared to BSL	
GDP (billion €'15)	-8.7%
<u>Total Final Energy by Sector (Mtoe)</u>	-6.2%
Heavy Industry	-5.4%
Other Industries	-3.8%
Residential	3.5%
Tertiary	-4.0%
Transport	-17.1%
<u>Energy related CO₂ emissions (MtCO₂)</u>	-10.8%
Power generation	-3.9%
Industry	-12.2%
of which energy intensive industries	-15.9%
Residential	3.5%
Services	-4.7%
Agriculture Energy	-0.3%
Transport	-23.2%
of which Road transport	-17.2%
of which Aviation	-55.3%

Source: PRIMES model

To assess the impacts of the crisis on the energy and climate targets and a potential increase in ambition, a revised baseline scenario (COVID-BSL) was produced as well as a scenario achieving 55% GHG emission reduction in 2030 (COVID-MIX). These scenarios are modified on some of the variables that the crisis impacted (e.g. activity levels or fuel prices – described in sections 9.3.2.1 and 9.3.2.2). The results for the COVID-BSL can be found in detail in 9.3.3.1. The COVID-BSL indicates 1.1% lower GIC and 0.3% lower FEC compared to BSL in 2030.

Road transport is by far the sector that contributes the most to the fall in emissions in 2020 under COVID-BSL compared to BSL, with a difference between the two scenarios of 128 MtCO₂-eq (a 17.2% drop). In turn, emissions from aviation are expected to be about 55% lower under COVID-BSL than under BSL, with a fall in emissions of about 78 MtCO₂-eq. Overall, the reduction of energy emissions would amount to 250 MtCO₂-eq in the residential, tertiary, transport and industry sectors combined (-14.1%) and 40 MtCO₂-eq on the supply side (-4.4%), mostly stemming from power sector emission reductions. The main impact of the crisis on energy use is a reduced demand for energy services in the next decade. In 2025 and 2030, the lingering effects of the large shock are still measurable, but considerably smaller.

The reduction in economic activity reduces demand for ETS allowances which allows coal to have a slightly higher share in electricity generation in 2030. Yet, lower electricity demand means that the amount of total electricity generated by coal in 2030 is low. Reduced economic activity implies that less deployment of renewable energy is needed to reach the same objective. By 2030, however, the change in RES shares is limited compared to MIX. Lower final energy demand, on the other hand, implies slightly higher savings compared to the 2007 baseline projections used as reference. Table 18 compares the key climate and energy policy parameters for 2030 in the MIX and COVID-MIX scenarios.

Table 18: Comparison of key climate and energy policy parameters in the MIX and COVID-MIX scenarios

	2030	
	MIX	COVID-MIX
GHG reductions compared to 1990¹⁴⁷	-55.1%	-55.4%
GHG ETS stationary installation compared to 2005	-65%	-66%
ESR current scope	-38%	-39%
Overall RES share (%)	38.4	38.4
RES heating and cooling share (%)	39.6	39.6
RES electricity share (%)	65.0	65.0
RES transport share (%)	23.7	23.5
Final Energy savings w.r.t. to baseline projection (%)	-35.9	-36.9
Primary Energy savings w.r.t. to baseline projection (%)	-39.7	-40.6

Source: PRIMES model

Energy system costs are projected to be significantly lower under COVID-BSL and COVID-MIX than under BSL and MIX, both in absolute terms and as a share of GDP, even though GDP itself is projected to remain lower than previously anticipated all the way to 2030 (Table 19 and Table 20). As elaborated upon in annex 9.3.2.2, international fuel prices have been significantly hit by the COVID crisis and the effect is projected to persist to some extent to 2030. The energy purchase component of energy system costs is therefore significantly lower under COVID than based on the pre-crisis assumptions. In addition, energy system costs including carbon pricing payments are impacted by the lower ETS carbon price under COVID-MIX than under MIX.

In turn, the capital costs and direct efficiency investment costs component of energy system costs differ relatively little between MIX and COVID-MIX. This is due to the fact that the scale and nature of investments needed to achieve the 55% level of ambition differ very little between MIX and MIX-COVID (see below).

¹⁴⁷ Including LULUCF, including intra EU aviation and navigation

Table 19: Average annual Energy System Costs, COVID sensitivity analysis (excluding carbon pricing payments and disutility costs)

Energy System Costs (€'15)*		BSL	MIX	COVID-BSL	COVID-MIX
in bn (average annual)	2021-'30	1,593	1,626	1,463	1,493
	2031-'50	1,774	1,926	1,708	1,862
% of GDP (average annual)	2021-'30	10.7%	11.0%	9.9%	10.1%
	2031-'50	9.9%	10.8%	9.6%	10.4%
in bn	2030	1,700	1,743	1,647	1,685
	2050	1,851	2,109	1,777	2,034
% of GDP	2030	10.9%	11.1%	10.5%	10.8%
	2050	9.1%	10.4%	8.8%	10.1%

Note: * Energy System Costs in 2015 are estimated at €1,340 billion (10.6% of GDP).

Source: PRIMES model

Table 20: Energy System Costs, COVID sensitivity analysis (including carbon pricing payments and disutility costs)

Energy System Costs (incl. carbon pricing payments, excl. disutility costs)		BSL	MIX	COVID-BSL	COVID-MIX
in bn €'15 (average annual)	2021-'30	1,610	1,673	1,480	1,533
	2031-'50	1,796	2,013	1,729	1,942
in bn €'15	2030	1,716	1,798	1,661	1,728

Source: PRIMES model

A critical conclusion that can be drawn from the COVID sensitivity analysis indeed relates to investment needs, which are not affected to any significant extent. To achieve the 55% GHG reduction level, the COVID-MIX scenario still requires a similar absolute amount of investments in the energy system, no matter the economic situation (Table 21). The incremental level of energy system investment required between COVID-BSL and COVID-MIX is also very similar to the additional level of investment required between BSL and MIX, both in the aggregate and in terms of individual supply and demand side components.

The current economic recession and the limited negative impact on output projected by 2030 therefore do not reduce the need to invest strongly in the coming decade to meet these emission reduction objectives. More efficient and better insulated buildings, electric cars, continued rapid penetration of renewable energy in all sectors are all still needed to achieve the transition towards climate neutrality. It must be noted also that significant behavioural changes relating to consumption habits and mobility patterns were not assumed to take place to any significant extent under the COVID scenario. As indicated in the in-depth analysis in support of the Communication “A clean planet for all”, however, such behavioural changes are susceptible to reduce investment needs if they are adopted widely and to a significant extent.

Table 21: Annual energy system investment, COVID sensitivity analysis (2021-2030, billion euros 2015)

	BSL	MIX	Delta	COVID-BSL	COVID - MIX	Delta COVID
<u>Supply</u>	<u>94.7</u>	<u>119.9</u>	<u>25.2</u>	<u>92.5</u>	<u>116.5</u>	<u>24.0</u>
Power grid	50.5	58.2	7.7	48.8	56.5	7.7
Power plants	42.1	56.5	14.4	41.4	54.8	13.4
Boilers	2.0	3.8	1.8	2.2	3.9	1.7
New fuels	0.2	1.4	1.3	0.2	1.3	1.1
<u>Demand excl. transport</u>	<u>241.3</u>	<u>298.0</u>	<u>56.7</u>	<u>232.2</u>	<u>293.3</u>	<u>61.0</u>
Industry	16.9	20.3	3.4	13.5	19.0	5.5
Residential	151.2	190.0	38.8	148.1	188.3	40.3
Tertiary	73.2	87.7	14.5	70.7	86.0	15.3
<u>Transport</u>	<u>610.5</u>	<u>621.8</u>	<u>11.3</u>	<u>593.7</u>	<u>607.4</u>	<u>13.7</u>
<u>TOTAL</u>	<u>946.5</u>	<u>1039.7</u>	<u>93.2</u>	<u>918.5</u>	<u>1017.2</u>	<u>98.7</u>
<i>TOTAL excl. transport</i>	<i>336.0</i>	<i>417.8</i>	<i>81.8</i>	<i>324.8</i>	<i>409.8</i>	<i>85.0</i>
<u>Memorandum:</u>						
<i>Real GDP</i>	<i>14839.7</i>	<i>14839.7</i>		<i>14329.5</i>	<i>14329.5</i>	

Source: PRIMES model

While investments in the necessary green capital goods improve overall resource efficiency and stimulate more sustainable long-term growth, triggering them at the necessary scale in the current circumstance will be even more challenging than before the crisis and will require additional incentives coupled with a supportive regulatory environment. The scale and focus of the recovery packages currently being put in place at the level of the EU and individual Member States therefore will be of importance for the achievement of a higher level of climate ambition by 2030 and socially and environmentally sustainable growth, in a context where private investors may face challenging financial situations.

6.5 Social impacts and just transition of achieving combinations of GHG/RES/EE ambition levels

6.5.1 Impact on employment

Section 6.4.2 concluded that the impact of increased climate ambition on aggregate output by 2030 would be relatively limited, but that it would have significant repercussions on the sectoral composition of GDP. These repercussions would obviously affect the labour market directly. At the aggregate level, the macro-economic models also do not show very significant effects on employment. In general, more than issues related to climate and energy policy, the performance of labour markets are driven to a much larger extent by the latter's structural characteristics and potential frictions, e.g. in matching labour supply and demand and ensuring that education and training track the skills needs of the economy. Under the standard setup of the JRC-GEM-E3 model, wages are fully flexible and unemployment remains at the level of the baseline, which means that aggregate employment is not affected at all. The model can nevertheless represent imperfections in the labour market and involuntary unemployment. In such a setting, together

with the lump-sum redistribution of carbon revenue to households, the 55% fragmented action scenario generates a small negative effect on aggregate employment by 2030, equivalent to a loss of around 494 000 jobs (0.26%) in 2030.

However, if carbon revenues are used instead to reduce labour taxation, the reduction in associated distortions and impact on labour costs is susceptible to generate a limited positive impact on aggregate employment under the 55% fragmented action scenario, equivalent to an increase of around 110 000 jobs (0.06%) in 2030 (Table 22).

Table 22: Impact of policies and modelling assumptions on employment to achieve 55% GHG reductions in case of fragmented action at the global scale (deviation from baseline, percent)

<u>Policy setup</u>	- Lump sum transfers - Imperfect labour market - Free allocation ETS - Scope extension ETS - No carbon pricing non-ETS	- Tax recycling - Imperfect labour market - Free allocation ETS - Scope extension ETS - No carbon pricing non-ETS	- Tax recycling - Imperfect labour market - Free allocation ETS - Scope extension ETS - Carbon pricing non-ETS
JRC-GEM-E3*	-0.26	0.06	0.05
<u>Policy setup</u>	- Lump sum transfers - Free allocation ETS - No carbon pricing non-ETS	- Tax recycling - Free allocation ETS - Carbon pricing non-ETS	- Tax recycling - Auctioning ETS - Carbon pricing non-ETS
E3ME	0.01	0.16	0.20
<u>Policy setup</u>	Lump sum transfers	Lower taxation low-skilled labour	Support green invest.
E-QUEST	-0.09	0.45	0.02
* All JRC-GEM-E3 scenarios assume free allocation in ETS industry and auctioning in the power sector (as well as buildings and road transport in case of scope extension ETS). For industrial sectors it is assumed companies cannot incorporate the opportunity cost of free allocation and thus optimise market share.			

Source: JRC-GEM-E3 model, Cambridge Econometrics and DG ECFIN

The E3ME and E-QUEST models are somewhat more optimistic in terms of aggregate employment, but the impacts are expected to remain limited under any circumstances. E3ME projects no change in employment under the assumption of lump-sum transfer of carbon revenues to households. If carbon revenues are recycled to support energy efficiency investment and reduce VAT, the impetus provided to consumption and GDP generates an increase in employment of up to 0.20% relative to baseline, an increase of 412 000 jobs.

E-QUEST indicates that using carbon revenue to reduce labour taxation for the lower-skilled segments of the labour force can increase total employment by 0.45% in 2030 under a 55% level of ambition. Such a targeted reduction in labour taxation stimulates low-skilled labour supply via higher net wages while simultaneously lowering low-skilled labour costs for firms, thereby leading to higher overall employment. The tax shift also positively impacts the external competitiveness of domestic firms.

The models also converge in their assessment of impacts on the sectoral composition of employment, which can indeed be very significant. This underlines the challenges related to just transition and the need to address distributional issues fully and with adequate instruments (section 6.5.2, section 9.11.4). Employment in the coal sector, in particular, is expected to be

around 50% below baseline by 2030 (Table 23). Given that the baseline already factors in a significant reduction in coal employment, this means that the number of jobs in the sector would fall dramatically over the next decade. While this is not consequential in terms of total employment at the EU level, it has severe implications for some regions and local communities. By 2030, employment in the coal sector projected in the JRC-GEM-E3 model could drop to around 65 000 jobs. Employment in other fossil-fuel sectors is expected to fall significantly as well, though less severely than for coal. The public expressed a slight preference for economic diversification and modernisation away from fossil fuels to ensure a just transition and employment.

Table 23: Impacts of 50% and 55% reduction on EU sectoral employment (deviation from baseline, percent)

Employment vs. baseline, 2030				
	50%		55%	
	<u>Fragmented action</u>	<u>Global action</u>	<u>Fragmented action</u>	<u>Global action</u>
Coal	-18.5 -17.2	-17.5 -16.0	-49.1 -48.3	-47.1 -46.3
Crude Oil	-7.3 -4.3	-9.6 -8.0	-8.1 -4.8	-10.5 -8.6
Oil	-4.8 -2.9	-7.4 -5.6	-5.2 -3.1	-7.9 -5.7
Gas	-15.7 -13.4	-12.8 -11.2	-11.2 -8.5	-7.9 -5.8
Electricity supply	0.1 0.6	3.3 4.1	2.8 3.3	5.7 6.6
Ferrous metals	-3.5 0.5	3.1 7.5	-4.1 0.1	2.2 7.0
Non-ferrous metals	-1.6 0.5	4.4 7.0	-2.2 -0.1	3.6 6.3
Chemical products	-0.7 0.1	0.8 1.6	-0.8 -0.1	0.6 1.4
Paper products	-0.3 0.2	0.2 0.8	-0.4 0.1	0.0 0.7
Non-metallic minerals	-1.6 0.6	0.5 3.1	-2.1 0.3	-0.1 2.7
Other equipment goods	-0.1 0.6	2.2 3.0	-0.3 0.4	2.0 2.8
Consumer goods	-0.4 0.4	-0.5 0.5	-0.6 0.3	-0.6 0.4
Construction	0.7 1.0	0.4 0.7	0.3 0.6	-0.1 0.4
Transport (air)	-3.4 0.5	-3.1 1.2	-3.7 0.5	-3.8 1.5
Transport (land)	-0.3 0.2	-0.4 0.1	-0.5 0.0	-0.7 0.1
Transport (water)	-0.2 0.3	-3.9 -3.0	-0.3 0.2	-4.1 -2.9
Market services	-0.3 0.1	-1.3 -0.8	-0.3 0.1	-1.4 -0.7

Source: JRC-GEM-E3 model

The employment impacts in energy intensive industries is expected to track closely the impact on output in these sectors. The policy setting, as reflected in the various model setups, is therefore a major determinant of impacts. Employment in ferrous metals is likely to be most affected, followed by non-metallic minerals, as these sectors are more open to international trade and competition. In the absence of complementary policies (recycling of carbon revenues to lower labour taxes, free ETS allowances), employment in ferrous metals could be up to around 4% below baseline in 2030 under the 55% fragmented action scenario. Complementary policies could nevertheless avoid negative impacts on employment altogether or generate a small positive impact relative to baseline, in ferrous metals as well as in other energy-intensive industries.

Sectors that are likely to gain most significantly from a higher level of climate ambition by 2030 include electricity supply and construction. The electrification of the economy and the switch to renewables, which tend to be relatively labour intensive, are naturally expected to generate higher

employment in the sector. The need to increase the energy efficiency of buildings, in turn, should trigger higher employment in construction and the equipment goods industry. Market services, by far the largest provider of jobs in the EU, would be affected relatively little under most model setups. The bio economy, in particular through the production of bio methane, is likely to play an increasingly important role that will bring income to rural areas. According to stakeholders, bio methane would, in particular, benefit from fewer legal barriers and increased cross-border trade¹⁴⁸.

The expected significant shifts in the sectoral composition of employment and the associated job changes that workers will have to go through¹⁴⁹ over the next decade under higher climate ambition would generate challenges for the labour market and the labour force. The nature of the challenges relate to the ability of workers to move from a job in a given sector and occupation to another sector and potentially another occupation requiring different skills. They also relate to the ability of the labour market to match labour demand and labour supply, and the ability of the education and vocational training systems to train or re-train workers, which would call for significant investment in human capital by individuals, firms and the public sector. Regional shifts in employment, e.g. with employment creation and employment destruction potentially occurring in different locations, create additional challenges when labour mobility across regions and/or countries is constrained.

Macro-economic models fail to capture the additional transformations that could be expected within sectors and which could amplify such challenges. The construction or market services sectors, for example, are far from homogenous and are likely to be affected by the climate and energy transition. A strong focus on buildings renovations and higher energy efficiency stands would for instance necessitate specific skills from construction workers.

An effort is made to assess the impacts on skill needs due to these employment shifts between sectors (see annex 9.5.3 for a description of the methodology). Without policies that reduce labour tax, high skill levels appear to be more negatively impacted than low skills levels. The main driver here is the specific sectoral output losses and related job losses as projected in the JRC-GEM-E3 model under these settings which impacts high skill level employment in industrial sectors relatively more. However, the same model when assuming a policy set up of tax recycling of carbon revenue and carbon pricing across the economy, projects that the total employment would be positively affected by 2030 under the 55% fragmented action scenario. Under such a setup, all skill levels see employment gains compared to baseline, but with a more limited impact on high skills employment.

¹⁴⁸ Gas Distributors for Sustainability (GD4S) (2020): “Renewable gases in the European Green Deal”.

¹⁴⁹ For example transitioning from a job in a sector experiencing net losses in employment to a new job in another sector, or transitioning within sector but to a different job more aligned with the needs of the green economy.

Table 24: Impacts on employment by skills levels (deviation from baseline, percent, 55% scenario (MIX), fragmented action)

Employment vs. baseline, 2030			
	Lump sum transfers Perfect labour market Profit maximisation Free allowances	Lump sum transfers Imperfect labour market Market share max. Free allowances	Tax recycling Imperfect labour market Market share max. Free allowances
Low skill levels	0.08	-0.17	0.15
Medium skill levels	0.01	-0.25	0.08
High skill levels	-0.04	-0.31	0.00

Source: JRC-GEM-E3 model, using CEDEFOP forecast

When it comes to occupations, demand for craft and related trades workers would be one of the sectors positively impacted most (or least negatively affected). Plant and machine operators and elementary occupations would also benefit from a more favourable outcome under a scenario where carbon revenues are recycled to reduce labour taxation. Similarly, jobs in agriculture would rise, though total employment in the sector is small in relative terms. Overall, it must be noted that these results represent relatively small changes in the policy scenarios compared to baseline.

Table 25: Impacts on employment by occupation (deviation from baseline, percent, 55% scenario (MIX), fragmented action)

Employment vs. baseline, 2030			
	Lump sum transfers Perfect labour market Profit maximisation Free allowances	Lump sum transfer Imperfect labour market Market share max. Free allowances	Tax recycling Imperfect labour market Market share max. Free allowances
Managers	-0.02	-0.33	0.04
Professionals	-0.07	-0.30	-0.04
Technicians and associate professionals	-0.06	-0.31	-0.02
Clerks	-0.05	-0.31	0.00
Service and sales workers	-0.04	-0.31	-0.05
Skilled agricultural workers	1.25	0.93	1.37
Craft and related trades workers	0.07	-0.20	0.21
Plant and machine operators and assemblers	-0.21	-0.50	-0.03
Elementary occupations	0.09	-0.18	0.14

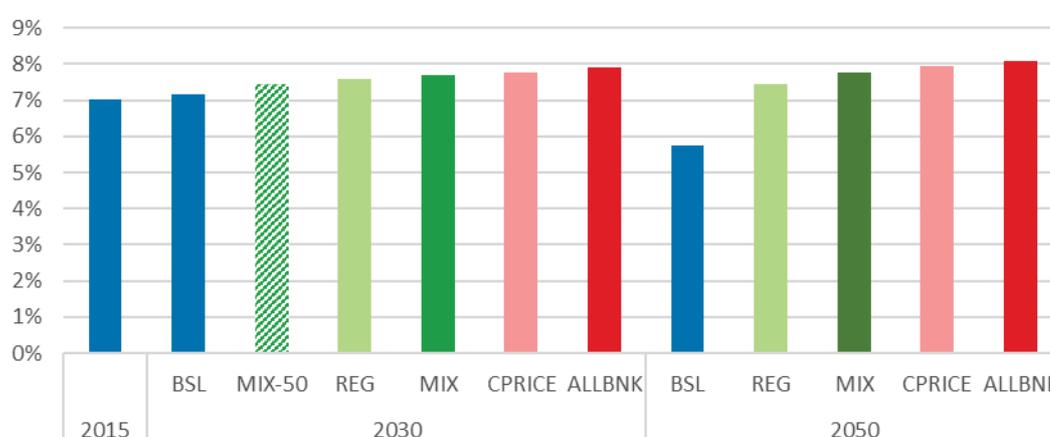
Source: JRC-GEM-E3 model, using CEDEFOP forecast

6.5.2 Impact on households

Under BSL, annual energy related expenses (excluding transport) per household are projected to increase from EUR 2 575 in 2015 to EUR 3 099 in 2030, a 20% increase. In the policy scenarios, the annual energy related expenses per household increase in 2030 (compared to 2015) by 23% in MIX-50 and up to 28% in REG and ALLBNK.

On the other hand, household income is also projected to increase. As a result, the share of energy expenditures in household income reaches a plateau of around 7% in 2025-30 under BSL and slowly declines afterwards. In the policy scenarios, these changes amplify and vary, reflecting the underlying assumptions of each scenario. In the REG scenario, with its strong investments in energy efficiency in 2030, households spend on energy 7.6% of their income – a modest increase compared to BSL. Energy related costs in MIX and CPRICE amount to 7.7% and 7.8% respectively. MIX-50 represents the lower and ALLBNK the upper range of results but in both cases difference with other policy scenarios is small. Figure 15 shows the evolution of households' expenditures in 2030 and in 2050.

Figure 15: Buildings-related household energy expenses (% of income)

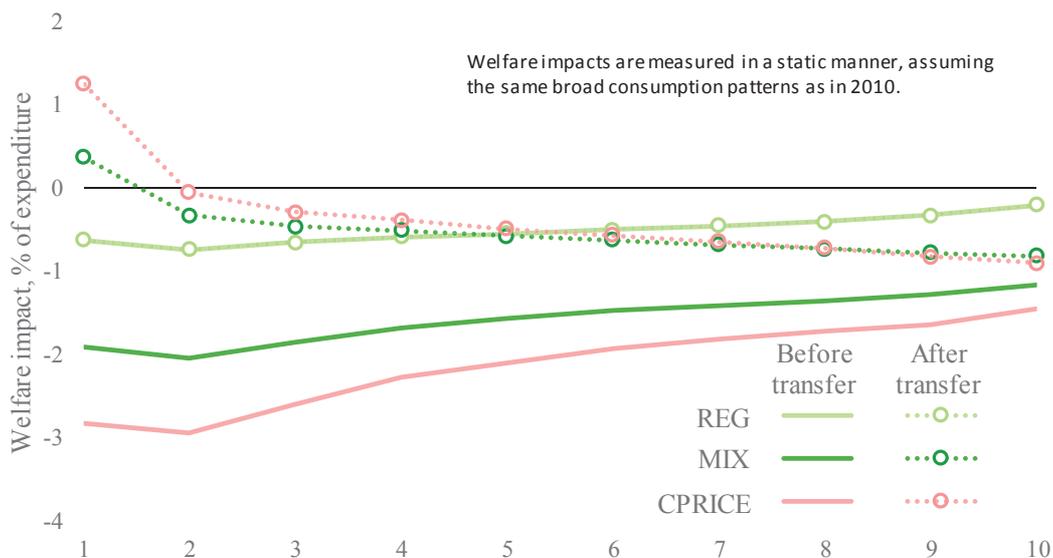


Source: PRIMES model

As indicated in section 6.4.2, macro-economic models indicate that a higher level of climate ambition for 2030 will affect relative consumer prices in the economy. These changes affect households in contrasted manners that depend on their expenditure structure, level and sources of incomes, wealth and the very composition of the household. Given that macro-economic models frequently represent one or a limited number of representative households, detailed distributional impacts can be assessed with the support of micro-level data.

The analysis combines the JRC-GEM-E3 model with the household budget survey (HBS) of 2010 to estimate distributional effects on households at EU level and by expenditure (income) deciles (see annex 9.5.3 for a description of the methodology). The estimated changes in relative prices generated by higher climate ambition (fragmented action REG, MIX and CPRICE scenarios at 55% level of ambition, as per section 6.4.2, in particular Table 15) would affect lower income earners (or households in the lower deciles in terms of expenditure) significantly more than the top income earners (or households in the upper deciles in terms of expenditure) – see Figure 16.

Figure 16: Changes in relative welfare by expenditure decile due to changes in relative prices (fragmented action REG, MIX and CPRICE scenarios with 55% level of ambition)



Source: JRC-GEM-E3 model

Relative increases in fuel and power prices are more significant under MIX and CPRICE than under REG, while the opposite is projected for housing prices. In the absence of redistribution, households in the lower expenditure deciles are more negatively impacted under MIX and CPRICE than under REG, as the effect of higher relative fuel and power prices dominates. It must be stressed that the analysis is static, showing the impact of increased energy and housing prices while assuming the same broad consumption patterns as in 2010. It does not take into account the evolution of energy consumption due to changes in efficiency over the 2010-2030 period or the impact of policies.

In addition, the data indicate that a lump-sum redistribution of carbon revenue at the national level (i.e. additional revenues relative to baseline are recycled within country) and based on household size¹⁵⁰ could generate a positive welfare impact on the bottom expenditure decile of the EU population as a whole under MIX and CPRICE, and sharply reduce the negative impact on all other expenditure classes. This analysis therefore points that the impact on relative welfare is limited across many expenditure groups, and that carbon revenue at national level would be sufficient to compensate those more significantly affected (see annex 9.5.3 for a short description of impacts on household groups by income deciles rather than expenditure deciles).¹⁵¹

The analysis presented in Figure 16 assumes that all revenues from carbon pricing are redistributed as a lump sum uniformly to all households, regardless of expenditure or income decile. As an actual policy, a redistribution mechanism could be significantly more targeted to address the needs of lower income/expenditure deciles. This would enable a higher degree of

¹⁵⁰ Household size measured on the basis of equivalent household size, using the modified OECD equivalence scale.

¹⁵¹ The analysis assesses the impact of changes in consumption prices relative to baseline. To evaluate the impact of the REG, MIX and CPRICE policy scenarios and the scope for mitigating the distributional effects, it therefore also takes into account only the amount of additional carbon revenues that is generated relative to baseline for redistribution purposes. Only MIX and CPRICE generate such additional revenues.

compensation for the households in need for any given level of revenue generated by carbon pricing.

In addition, a targeted redistribution mechanism could create room to use part of the carbon revenues to support sectoral restructuring. Section 6.4.2 indicated that using carbon revenues to reduce labour taxation reduces tax distortions and generates a “double dividend” by lowering business costs, improving competitiveness and increasing employment (see also section 6.5.1). Furthermore, carbon revenues can be used to provide more targeted support for sectoral restructuring, including for example via direct support for research and development, innovation and the deployment of new technologies at market scale. The use of carbon revenues therefore clearly involves a trade-off between the redistributive and economic restructuring objectives. The scale of resources involved clearly will also depend on choices made regarding the scope of sectors subject to carbon pricing. Finally, the scale of resources available at EU and national level will depend on a proposal regarding EU own resources.

A complementary analysis of distributional impacts on households was carried out with the GEM-E3-FIT model, which includes a module representing household income, consumption patterns and skills composition. The analysis indicates that income inequality as measured by the Gini coefficient is expected to increase by 2030 under BSL, in part as a result of changes in the composition of skills in demand. It also confirms the finding above that the increase in inequality in BSL can be at least in part reversed under the policy scenarios when carbon revenues are used for lump sum transfers for households. Finally results from the E3ME model, which projects overall positive GDP impacts of increase climate ambition (see Table 14, section 6.4.2), correspondingly project limited increases also for real household disposable income for all income deciles.

The trends in system costs presented in section 6.4.1.1 show how some policy options increase capital expenses while reducing energy cost. The investment trends presented in section 6.4.1.3 show how increased investments result in a reduction in consumption in part – but not entirely – related to a reduction in energy expenses. Overall, citizens will face increased costs for reducing emissions and energy consumption. However, part of those costs will be repaid in the form of saving on energy expenditure.

The benefit of energy savings will not be enjoyed equally by all citizens. Households with higher disposable income will be able to invest in both energy efficiency and distributed renewable energy generation. Households with lower income might lack the access to capital necessary to invest. As described above, this situation is worsened by the different spending patterns across deciles as lower income households tend to spend a higher share of income for purchasing energy services.

As possible negative outcome of the transition, households in the lower income deciles might have to compensate higher energy expenditures by reducing consumption of other goods. As energy cost are projected to increase, energy poverty could intensify if not adequately addressed¹⁵².

Several policies are possible to mitigate negative distributional effects. As mentioned above, a lump sum transfer (either direct or in the form of tax rebates) can compensate for the rising costs

¹⁵² [Employment and Social Developments in Europe 2019, chapter 4.](#)

of energy. Other options include means-tested support for energy investments (e.g. in the form of subsidies for energy efficiency measures) targeted to benefit mostly low-income households. Energy taxation also plays an important role in how the burden is shared among citizens. Progressive tax rates would have the effect of reducing the costs for vulnerable consumers. Furthermore, a tax shift from labour to carbon could be directed at the low-income segments of the labour market, for instance through earned income tax credit schemes.

As discussed above, the revenues from pricing carbon emissions are an obvious candidate for funding redistributive measures. All the options presented above present strong points and trade-offs, but a well-balanced portfolio of measures can largely reduce the unwanted distributional effects of climate policies. While not assessed in this Impact Assessment due to an ongoing update of the EU Reference Scenario on energy, transport and GHG emissions, these types of distributional impacts will also affect lower versus higher income Member States, with the former having in relative terms higher shares of low income households and higher exposure to related negative impacts. Similarly, Member States particularly hard hit by the COVID-19 pandemic might have a lower capability to address such issues within their own national budgets. Just like with individual households, distributional aspects across Member States will need to be fully addressed in order not to leave anybody behind. In anticipation, both the recently agreed EU budget 2021-2027 and the recovery and resilience package place major emphasis on promoting green investment in a just manner and thus mobilise significant financial resources towards lower income Member States and those that are particularly affected by the Covid-19 pandemic. In the coming months, the impact assessments accompanying future proposals in the context of this 2030 climate target plan will have to particularly address these distributional issues in light of the these budgetary decisions.

6.6 Assessment of the broad architecture of options on intensification of renewable energy, energy efficiency and transport policies

While this section looks at the impacts of policy scenarios and derives on this basis conclusions on future policy framework, annex 9.6 complements this assessment with indication of future policy tools that could correspond to assumptions made in policy scenarios.

For renewable energy, energy efficiency and transport, the four policy options related to the policy framework presented in sections 5.2.2.2, 5.2.2.3 and 5.2.2.4 (no, low, moderate and high ambition increase) were reflected in the scenario set-up. These policy options are needed to deliver the increased GHG target and result in increased level of ambition for renewable energy and energy efficiency.

These policy options can be implemented at European or national level, with sectoral or cross-sectoral tools, in form of regulatory or softer measures and would often interact with other pieces of legislation. The measures foreseen under the policy options are necessary to remove the current barriers and market failures to the uptake of renewable energy and energy efficiency (including in transport) and thus pave the way for the cost-effective decarbonisation of the energy system.

Achieving the GHG target of 55% would require a moderate (MIX) or high (REG) increase of both energy efficiency, renewables and transport policy framework across all energy system sectors, unless the decision would be to rely on strengthened carbon pricing and some transport policies (CPRICE, see section 6.8 for the discussion of such a scenario). GHG target of 50%

(MIX-50) would require low ambition increase of energy efficiency, renewables and transport policy framework.

Contrasting the REG, MIX, MIX-50 and CPRICE scenario results enables to see how the environmental, social and economic impacts change depending on the overall policy framework. Importantly, the results of these scenarios must be attributed to all drivers, i.e. the overall architecture of measures represented by the scenarios.

As indicated in section 4, this analysis leads to broad indications as to the type of policies to be pursued preparing ground for full analysis accompanying the upcoming legislative proposals in 2021.

Environmental impacts

All scenarios clearly show that efforts in moderating energy demand and increased deployment of renewables across all sectors (including transport) are essential to deliver the increased climate ambition towards 50% and 55% GHG emissions reductions in 2030 and the objective of the climate neutrality in 2050.¹⁵³

When comparing different scenarios illustrating different policy architectures allowing the achievement of the 55% GHG target, the scale of reductions in final energy consumption and the scale of deployment of renewable energy follows the scale of the intensification of energy efficiency and renewable policies. These policies are effective in impacting energy end-users in their choices towards energy efficiency measures adoption/renewable energy uptake and corresponding investments.

In REG, overall ambition for renewables deployment and (primary and final) energy savings is comparatively higher than in MIX, which in turn achieves higher results than CPRICE. ALLBNK, with higher domestic GHG reduction effort than other scenarios has even higher ambition in renewables deployment (and consequently in primary energy savings) than REG. Lower GHG target in MIX-50 leads to lower overall renewables share and lowest savings in final energy consumption. These patterns remain unchanged when discussing specific sectors. The sections below mainly discuss REG, MIX and CPRICE scenarios achieving the same 55% GHG target and differentiating only the policy set-up.

All scenarios show that for the end use sectors GHG reduction efforts are the highest in buildings (both residential and services¹⁵⁴). The large decarbonisation potential of these sectors already is and can be addressed by further intensification of current EE and RES policies.

¹⁵³ In the public consultation, the highest ranked options for renewable energy measures are to increase renewable electricity production, including necessary infrastructure, measures to support innovation related to renewable energy production, and measures to incentivise a more Europe-wide approach for renewable energy. For energy efficiency measures, the responses favoured more stringent energy performance requirements for transport vehicles, making the “Energy Efficiency First” principle a compulsory test in relevant decisions, and standards for the ICT sector to promote energy efficiency.

¹⁵⁴ The assessment encountered the main limitation that some sub-sectors are hard to be captured in statistics and in modelling and therefore a proper assessment of the impact on energy consumption and GHG emissions could not be made in this IA. As current studies are projecting a steady increase in electricity consumption in the ICT sector and on data centers (P. Bertoldi, M. Avgerinou, L. Castellazzi, Trends in data centre energy consumption under the European Code of Conduct for Data Centre Energy Efficiency, EUR 28874 EN, Publications Office of the European Union,

The moderate and high intensification of the measures directed to the buildings sector (residential and services sector) in REG and MIX show that energy efficiency measures targeting an acceleration of renovations rates and increasing renovation depths combined with an uptake of renewable technologies in heating and cooling (notably heat pumps) are indeed effective policies to achieve higher climate ambition. Modelling shows that it is more cost-efficient to increase the depth of renovations towards deep renovation and through a holistic approach combining measures in the building envelope with the upgrading of the heating systems and integrating renewable energy solutions. This approach delivers more energy savings and can reduce emissions from the building sector in a more sustainable manner as compared to lighter renovations which increase to a relative larger degree in the BSL. While regulatory measures of the existing legal framework would need to be reinforced to achieve such effect, the financing and enabling conditions would be critical, especially for higher energy efficiency ambition.

In the services sector, further analysis (in addition to scenarios modelled) will be needed regarding the ICT sector. Given the increasing demand for ICT services and data, the electricity demand for data handling is expected to grow. Further analysis is needed to see how further reduction of energy demand and promote waste heat reuse could be implemented in practice in this sector.

As regards industry, slightly contrasted finding can be shown on overall energy demand and on the fuel mix switch. CPRICE achieves higher GHG reduction in this sector thanks to carbon price while reductions are smaller in REG and MIX. Nevertheless, these scenarios assume only a generic incentive to increase efficiency therefore a more specific analysis would be needed to assess the policy elements indicated in the strengthened policy framework for industry. This applies in particular to better implementation of energy audits, which have proven to identify well the potential for energy savings, but are not always followed-up by necessary actions as well as potential for waste heat reuse¹⁵⁵.

Finally, for transport, a combination of vehicle/vessels/aircraft efficiency improvements, fuel mix changes, greater use of more sustainable transport modes and multi-modal solutions, digitalisation, smart traffic and mobility management, road pricing and incentives driving behavioural changes in REG could have further positive impacts on reduction of transport externalities. In addition significant impact is made by more stringent CO₂ standards for vehicles and the fuel mandates. The decarbonisation of transport in the MIX scenario would require ensuring synergies between the strengthened legislative framework and carbon pricing incentives in road transport.

Luxembourg, 2017, ISBN 978-92-79-76445-5, doi:10.2760/358256, JRC108354), and given the specific mandate provided in the Green Deal Digital/data strategy, EU-level measures addressing energy efficiency in this sector will need to be considered in dedicated future assessment of energy efficiency policies.

¹⁵⁵ This is the case for the policy option of re-using waste-heat from high to medium temperature combustion processes, for which further assessment would be needed to better understand the energy savings which could be achieved cost-effectively and the framework of measures which would be needed to remove the regulatory barriers preventing it. Further and dedicated analysis would also be needed to assess the role of measures bridging the gap between company audit results and their implementation. Alongside with EU-level measures, national schemes which are in place to implement the annual energy savings goal (Art. 7 of the EED) could also be directed more towards companies (both large and SMEs), by replicating or scaling up the existing best practices.

Across all sectors, the modelling results point to positive environmental impacts of further electrification of the economy - a key avenue for energy system integration and thus cost-effective decarbonisation¹⁵⁶ - in particular in road transport and low to medium temperature heating and cooling, driven by moderate and high intensification of renewable and energy efficiency policies.

Economic impacts

High intensification of energy and transport policies in REG requires significantly higher investments (mainly linked to increased renovations as well as heating equipment change in residential and services sectors) than other options achieving the same GHG ambition, but the upfront capital costs are later compensated by the energy purchases expenditure reductions. CPRICE scenario is constructed differently and - as a result of relying principally on the carbon price and not on policies - has lower upfront capital costs (notably linked to renovations) but higher energy purchases costs throughout the projection period. Impacts on investments (annualised) and energy purchase lead to differences in energy system costs of the scenarios.

In general, the variation of energy system costs for the increased GHG ambition is limited. Looking at the energy system costs excluding carbon allowances payments and excluding disutilities in the 2021-30 perspective: CPRICE appears as the scenario with lowest costs, with MIX being very close to CPRICE, and REG being more expensive. The situation actually reverses when carbon pricing payments and disutilities are included, where the REG scenario presents the lowest cost. In the 2031-50 perspective, the differences in system costs including carbon pricing payments and disutility costs become more amplified, with REG being significantly lower than other scenarios because of the long-term benefits of energy efficiency measures of this scenario.

Clearly, taking into account considerable investment needs across all scenarios, an optimal allocation of investments in the energy system where they make most economic sense is of importance. This is reflected in modelling where investments are optimised with availability of RES resources and EE potentials, which contributes to reducing energy system costs. In policy terms, this underpins the importance of EU initiatives whose aim is to optimise the functioning of the energy system in line with the recently adopted Strategy for Energy System Integration¹⁵⁷ and the Hydrogen Strategy¹⁵⁸.

Alongside the increase in system costs, significant additional (to BSL) savings in terms of fossil fuel import bills (0.1-0.2% of GDP in 2030) are also projected for all scenarios. These savings are similar across various pathways, though they are slightly higher with energy and transport policies most intensified, i.e. in scenario REG.

¹⁵⁶ Renewables-based electrification can make power systems more flexible e.g. by smart charging and use of so-called vehicle-to-grid services in transport, and resilient e.g. due to less exposure to volatility of international fuel prices, while making the wider energy system more secure and less reliant on fossil fuels. At the same time, it offers significant efficiency gains in primary energy use. It reduces pollution, leading to improved health. The modern automation and control systems that are an integral part of renewables-based electrification can also boost economic productivity and improve the quality of living conditions.

¹⁵⁷ COM(2020) 299 final

¹⁵⁸ COM(2020) 301 final

Social impacts

In the previous sections it becomes apparent that the rising cost of energy required to decarbonise the system has some impact on the share of income which the European households spend on energy. In all scenarios, households spend a higher share of their income on (energy-related) equipment and a smaller share on fuel expenditure (see section 6.5.2). The key benefit of more ambitious EE and RES policies is in better shielding of consumers from the impact of increasing energy prices both in the buildings sector (residential and services). Importantly, this effect amplifies over time.

While impact of the higher GHG ambition on relative welfare across income groups even without redistribution measures seems limited, targeted measures to protect low-income or vulnerable consumers should be intensified. Energy policies can help better protect vulnerable consumers who most often inhabit buildings with low energy performance and that would benefit most from deep renovations. Likewise, renewable policies, including those aiming to incentivise self-consumption, could also contribute to address energy poverty.

The social impacts of the increased ambition are first and foremost visible in terms of the heating bill and costs of renovations. To maximise the cost-effectiveness of policies, the worst performing building segments should be targeted as they are the ones maximizing effects on efficiency at a lower marginal cost. Such an effect could be achieved with measures targeting specific profiles of buildings owners and users as well as specific obstacles and barriers for their renovations. Conversely, a blanket economic disincentive alone (e.g. through a carbon price or via taxation) could be less effective in case of buildings owners with low income or in presence of split incentives. This example speaks also in favour of targeted measures to address specific market failures, designed in a way to maximise effects on emissions reduction, overall systems costs and addressing distributional effects.

A general conclusion on the future policy mix, is that both economic incentives and specific targeted regulatory measures are needed, the latter addressing market failures and barriers preventing energy efficiency and renewables investments (see annex 9.8).

6.7 Impacts of ETS extension and interaction with the ESR

This section takes an increased ambition as a starting point and summarises the impacts on the current key cross-sectoral climate policy instruments, the EU Emissions Trading System (ETS) and the Effort Sharing Regulation (ESR). The analysis focuses on a GHG ambition level of -55%. Starting from analysing policy impacts in the current scope of the two policy instruments, it then assesses different options to increase the role of carbon pricing notably by extending the scope of emissions trading. More detailed analysis is provided in annex 9.7.

6.7.1 Environmental impacts of policy aspects: impact on ETS and ESR

The existing 2030 climate and energy legislation features a target of -43% reduction in GHG emissions from the ETS sector compared with 2005, and -30% reduction in the ESR sectors to achieve at least -40% domestic GHG reduction compared with 1990. The increase in climate ambition to -50 to -55% below 1990 would lead to significantly higher GHG emission reductions than legislated both in the ETS and ESR sectors. Table 26 below provides an overview of the

emission reductions achieved for the current and different changes in sectoral scope of ETS and ESR based on the modelled scenarios.

The ETS sectors, even with a changed scope, are projected to reduce emissions more compared to 2005 than the ESR sectors, driven by the greater scale of cost-efficient emission reduction opportunities of the power sector, while industry reduces less. From the current ESR sectors, also buildings show a similar level of mitigation potential as ETS sectors with an increased energy efficiency already in the baseline and stepping up of fuel switching in the policy scenarios. In contrast, transport reduces less, with road transport only reducing a bit more than 25% over this period. For the current ESR sectors, the reductions would be -39 to -40% for -55% GHG. See annex 9.5.2.1 for more detail on the type of cost-efficient reductions achieved per sector under the different scenarios.

Table 26: ETS scope extension and projected ambition levels in ETS and ESR for different sectoral coverages

	BSL	MIX-50	REG	MIX	MIX-nonCO2 variant	C PRICE	ALL BNK
Total GHG vs 1990 (including intra EU aviation and navigation)							
GHG incl. LULUCF	-46.9%	-51.0%	-55.0%	-55.0%	-55.1%	-55.0%	-57.9%
GHG excl. LULUCF	-45.1%	-49.0%	-52.8%	-52.8%	-52.8%	-52.8%	-55.5%
ETS sector GHG % reductions vs 2005 given scope selected							
Stationary installations ETS	-55%	-60%	-65%	-65%	-64%	-65%	-69%
+ intra EU aviation (current scope) (option ETS_1)	-54%	-58%	-63%	-64%	-63%	-64%	-67%
+ all aviation + all navigation ¹⁵⁹	-47%	-52%	-57%	-57%	-56%	-57%	-61%
+ intra EU aviation + intra EU navigation	-52%	-57%	-62%	-62%	-61%	-63%	-66%
+ intra EU aviation + buildings + road transport	-47%	-51%	-56%	-56%	-55%	-56%	-58%
+ intra EU aviation & navigation + buildings + road transport	-46%	-%	-55%	-55%	-54%	-55%	-58%
+ intra EU aviation + road transport	-45%	-49%	-53%	-53%	-52%	-53%	-56%
+ intra EU aviation + buildings ¹⁶⁰	-55%	-60%	-65%	-65%	-64%	-65%	-68%
+ intra EU aviation + all energy CO ₂	-47%	-51%	-55%	-55%	-54%	-55%	-58%
ESR sector GHG % reductions vs 2005 in different scopes							
ESR current scope (option ETS_1)	-32%	-36%	-39%	-39%	-40%	-39%	-41%
ESR excl. buildings and road transport	-27%	-30%	-34%	-34%	-36%	-34%	-37%
ESR excl. road transport	-37%	-42%	-45%	-45%	-47%	-45%	-48%
ESR excl. buildings	-24%	-27%	-30%	-30%	-31%	-29%	-32%
ESR excl. all energy CO ₂	-23%	-26%	-30%	-30%	-33%	-30%	-33%

Note: The policy options analysed in this section are best reflected by those scenario results, which are not in italics. Policy option ETS_1 with the current ETS and ESR sectors is best reflected by the scenario keeping the EU ETS scope unchanged (REG). Options with additional sectors covered by emissions trading (options ETS_2.1 and ETS_2.2) are best reflected with scenarios further expanding carbon pricing (MIX-50, MIX, MIX-nonCO2, CPRICE and ALLBNK). Scenario results presented, which are not directly applicable, are presented in italics (e.g. BSL results for different sector scopes). Options ETS_3 and ETS_4 are not directly reflected by the scenarios, however can be approximated by the results of the MIX scenario.

Source: own calculations, PRIMES model, GAINS model

The results of the public consultation show that, when asked to prioritise the three key pieces of climate legislation (ETS, ESR and LULUCF), a majority of stakeholders believe that all the three pieces of legislation require an increase in the climate ambition. The ETS has the highest percentage of all stakeholders perceiving the legislation requires a substantially increased climate

¹⁵⁹ Due to modelling limitations, the PRIMES-GAINS estimates include inland navigation. However, the impact of this is small.

¹⁶⁰ “Building” emissions as used in the table mean emissions from domestic and commercial heating and cooking (not from electricity consumption which are covered by power supply). They are in the following and in the modelling results approximated by adding the emissions for the two GHG inventory sectors “residential” and “services”. It is acknowledged that services emissions includes also a small amount of ETS emissions and non-building emissions, while the public heat sector includes also district heating emissions including a small amount not covered by the ETS.

ambition, but at the same time it also had more stakeholders noting that it did not require additional ambition. Organised stakeholders rated the need for substantial increases in ESR reductions highest.

Impacts on the EU ETS for its current scope

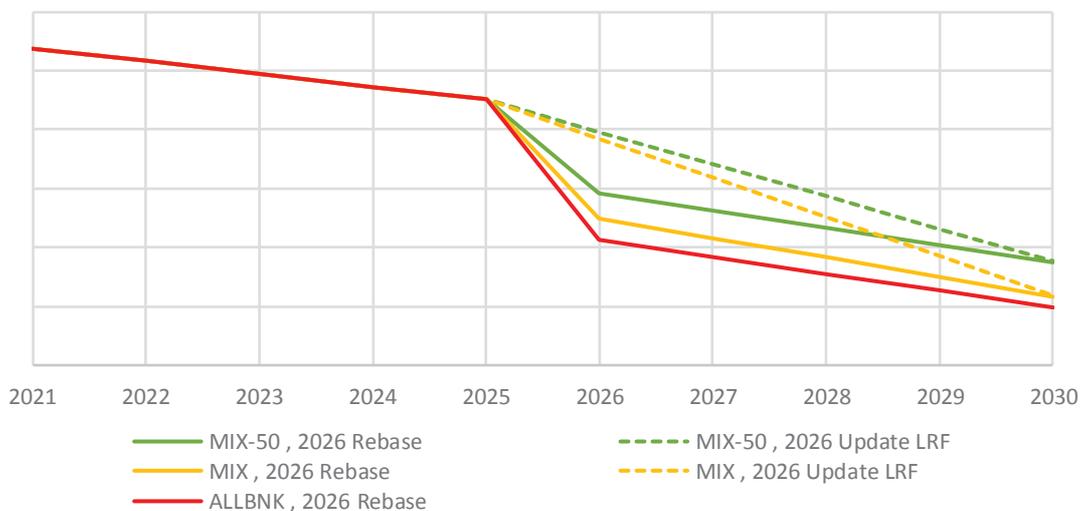
In policy option ETS_1 (the current ETS scope), the BSL scenario would achieve a 2030 emission reduction of -54% compared to 2005 while the policy scenario REG would achieve emission reductions of -63% by 2030 compared to 2005, increasing to -67% in ALLBNK¹⁶¹.

Reaching a 2030 cap in line with the emission projections under option ETS_1 for GHG reductions economy-wide would require a change of the ETS linear reduction factor, an update overall recognised as needed by stakeholders¹⁶².

A revised linear reduction factor is dependent not only on the 2030 ETS ambition but also on other elements including its starting year, the baseline level from which the LRF is applied and the scope. The Figure 17 gives a stylised representation of how the ETS stationary cap could evolve taking into account the projected scenario results. ALLBNK would result in the tightest cap for stationary installations because this scenario requires overall the largest reductions of domestic sectors. MIX of course results in a more stringent cap than MIX-50.

If for stationary installations not only the LRF gets reviewed at some point (in Figure 17 in 2026), but also its starting level (referred to in the below stylised example as ‘rebasings’) then the overall quantity of allowances over the period could further decrease. In Figure 17 the rebasing uses as the starting point 2025 emissions levels as projected in the different scenarios. With rebasing, the LRF needs to change less.

Figure 17: Stylised examples of how to update the ETS stationary cap



Source: Own calculations

Regarding scope, for policy purposes, the definition of the cap and LRF setting requires a robust and verified emissions data reference point. For the current ETS scope, the ETS Monitoring,

¹⁶¹ ETS ambition based on current ETS scope (including only intra-EU aviation).

¹⁶² E.g. Eurelectric response to the consultation

Reporting and Verification (MRV) system ensures the data robustness for the covered sectors, and for a possible scope extension a comparable system is required. This impact and the consistency with the overall framework will have to be further assessed in the subsequent policy review.

The installations covered by the ETS today are emitting less than the total cap. This gap between the cap and the actual emissions was estimated at around 250 million allowances in 2019 due to the large reduction of emissions. In the BSL scenario, this difference is projected to continue early on in the next decade. Accordingly, a large surplus of allowances is likely to remain in the system thereby potentially preventing it from delivering the necessary investment signal to reduce GHG emissions in a cost-efficient manner. This may only be addressed if the Market Stability Reserve is strengthened as part of its first review in 2021. Conversely, an update of the cap based on rebasing, rather than only updating the LRF will reduce faster any generation of an excess of allowances.

The implications of an increased ETS ambition on the architecture for addressing carbon leakage risks are assessed in section 6.9.

Impacts on the ESR for its current scope

The BSL scenario as well as the EU-NECP variant achieves a 2030 emission reduction of 32%. In line with the current ESR architecture and scope (option ETS_1), the REG policy scenario sees emissions reduced mainly through increased EE, RES, transport and some non-CO₂ policies, resulting for -55% GHG in an ESR reduction of 39% compared to 2005. This is achieved by significant additional reductions notably in the buildings sector, and to a lesser extent in the transport, non-CO₂ and non-ETS industry sectors.

Ensuring achievement of this emission reduction in the current policy architecture would imply translating this ambition level into more ambitious national 2030 targets, requiring a step up on average of 10 to 11 percentage points (p.p.) compared to the -29% EU27 aggregate resulting from the current ESR targets. 22% of all stakeholders (corresponding to around 40% of those with a view) support to increase ESR ambition in line with its cost-effective contribution. The large increase in emission reductions required points also to the need to consider additional EU level measures to facilitate achieving those. This would also require a change of the target trajectories. Based on the current ESR framework with its two five-yearly compliance cycles, this could be implemented for the second cycle in 2026-2030.

Contrary to this balanced approach, some Member States and 4% of all stakeholders have indicated that they want a focus on higher emission reductions in the ETS sectors instead of tightening further current ESR targets for increasing ambition. The realisation of some of the reduction potentials, e.g. in existing buildings and agriculture, is seen as more uncertain due to specific barriers. In the modelling results, the ETS sectors are already expected to reduce more (see Table 26). And a 5 p.p. additional ambition in the ETS sectors alone would imply at current ETS scope, a further increase of the ETS target to 70% and in turn a high linear reduction factor.

Impacts of changes of sectoral ETS coverage illustrated for a -55% GHG reduction

If additional sectors were to be covered by the ETS as in options ETS_2, ETS_3 and to a certain extent ETS_4, this would increase the likelihood of achieving the emission reductions in these sectors, and hence the EU's GHG target for 2030. With the resulting carbon prices, firms and households would have an additional economic incentive to reduce their emissions in the sectors newly covered by an ETS, and this incentive would rise, even countering possible rebound

effects from efficiency improvements and resulting cost reductions. It would also help in diffusing decarbonisation technologies more quickly. With buildings and road transport CO₂ emissions included in the ETS, around three quarters of the current total emissions (around two thirds in 2030) would be covered by an EU wide cap. This compares to around one third in 2030 in the current architecture. 55% of stakeholders favoured EU wide uniform carbon prices through ETS inclusion in the road transport sector, and 32% in the building sector, with another 32% preferring the option that carbon prices in this sector would differ from current ETS.

ETS emissions in the main variants of ETS_2 and ETS_3, that include the building and road transport sectors into the ETS or create (at least temporarily) a separate trading system for these sectors, reduce by 55 to 56% compared to 2005, which is less than in option ETS_1 without buildings and the road transport sector in the ETS. Of stakeholders which have a view on this question, 30% prefer that sectors covered by the ETS remain in the ESR (18% of all stakeholders), while 15% prefer to exclude them from the ESR (9% of all stakeholders).

The carbon pricing scenarios show clearly that building emissions are expected to respond significantly stronger to carbon prices than transport emissions, with additional reductions between 2015 and 2030 compared to the baseline of 14 to 15 p.p. for residential and 9 to 12 p.p. for services, compared to 3 p.p. for road transport. One reason is that in the transport sector, there are currently already often high explicit or implicit carbon prices through national carbon or energy taxation, unlike in the buildings sector, and therefore the additional incentive is smaller. For motor fuels, the EU27 unweighted average of implicit carbon prices of current MS nominal energy and carbon tax rates reported in the Taxes in Europe database amounts to around EUR 240 for petrol and around EUR 160 for diesel.

A strong point of options ETS_2 and ETS_3 is that the ETS has strong enforcement. It thus scores high on certainty to deliver the environmental outcome. The enforcement mechanisms in case of non-compliance with the obligations through the financial penalties under the EU ETS apply directly to the emitting entity. In the ESR the compliance obligation is on each Member State, through additional emission factors¹⁶³ and standard infringement procedures.

Option ETS_2.1 has some significant implications for the ESR. It would require a smaller numerical increase of Member State targets than in the current ESR scope, with emissions having to decrease by 34 to 36% instead of 39 to 40%. However, the ESR would lose around 55% of the current emission scope and the share of emissions covered by the ESR would decrease in 2030 from 66 to 67% in option ETS_1 to 32 to 33%. This would leave agriculture as the main remaining sector (CO₂ and non-CO₂ together around half of the remaining ESR scope), followed by industry with around 20% and waste and energy with both around 10% of the remaining ESR emissions. The major reduction in ESR scope could also lead to significant changes in Member State specific cost-efficiency gaps to achieve national targets based on fairness (GDP per capita) compared to the 2016 ESR impact assessment¹⁶⁴. The increased role of agriculture would also invite to revisit the role of the LULUCF flexibility, which has been designed to compensate for the comparatively lower technical mitigation potential of agriculture. See also section 6.10 on LULUCF for some further context and broader implications.

¹⁶³ If a Member State misses its ESR target in year x by 1 million tonnes, it would have to over-achieve its ESR target in the subsequent year by 1.08 million tonnes.

¹⁶⁴ SWD(2016) 247 final

The main variant of option ETS_3, which puts the buildings and road transport sector at least transitionally in a separate ETS, leads to two ETS systems of roughly similar size in 2030, each close to 35% of total emissions. One of the reasons for separate systems would be to first ensure their robustness, with expected early challenges associated including with a lack of a robust and verified emissions data reference for the cap setting in the new ETS.

Maintaining ESR coverage in a transitional manner for some sectors newly covered by emissions trading, as in options ETS_2.2 and ETS_3, can lead to a situation where sectors in the ESR that are also in the ETS, reduce more than needed in the ESR as a whole, allowing sectors not covered by the ETS in the ESR to do less than what would be cost-efficient. This risk would be reduced in case the scope expansion covers a large part of ESR emissions or if ESR targets are set higher. This risk could also be limited by specific ambitious EU measures in these sectors, such as the F-gas regulation and EU circular economy and waste legislation, or a further greening of the CAP.

Impacts of additional national carbon pricing measures

In option ETS_4, the current ETS/ESR architecture continues, and related architectural impacts described under option ETS_1 also apply. However, it is complemented by an additional carbon price incentive to reduce emissions, in principle created by a national system. An obligation to set up national trading systems would prioritise the certainty of the environmental impacts and counter rebound effects from cost reductions. National carbon taxation would have less certainty to achieve the targeted emission reductions. If collectively the national caps are set at a level below the EU ambition for the sectors covered by these national systems, option ETS_4 will not achieve the required EU wide GHG reduction.

Setting explicit minimum carbon price levels for these sectors by a revision of the EU energy taxation could mitigate internal market challenges by ensuring the same minimum carbon prices across all EU Member States, but in itself is no guarantee for delivery of the required emission reduction.

6.7.2 Economic impacts

The general economic impacts of an increased ETS and ESR ambition and various scenarios are assessed in section 6.4. Options with an emissions trading system at the EU level (options ETS_2 and 3) can assist in first incentivising the cheapest reductions across Member States, improving cost-efficiency in the sectors covered and delivering increased environmental certainty at the emission reductions to be achieved. This is not the case with a variant of option ETS_4 with a national carbon tax, or where national trading system do not add up to the required overall ambition level.

An extension of the EU ETS to new sectors such as in option ETS_2 would not only represent a significant expansion in the availability of abatement options across the EU, but also across sectors compared to the current situation. It would create a more integrated carbon market with a single carbon price, which could hence drive emission reductions where they are overall most cost-efficient. It would ensure the maximum cost-efficiency and not distort the single market.

By contrast, options ETS_3 and ETS_4 could lead to different carbon prices for the buildings and road transport sectors, the current EU ETS sectors, or across Member States, and could therefore possibly be more adapted to diverse abatement potentials and ability to pay of different sectors and Member States. This needs to be weighed against the problems, which the different national

prices or different prices in different sectors, may create for the level playing field in the single market, in particular but not only in road transport.

Covering building emissions fully by the current ETS (options ETS_2.1 and ETS_2.2) would provide a level playing field in terms of carbon pricing of domestic fossil-fuelled heating systems with district heating and electric heating already now covered by the ETS. Similarly, covering road transport emissions fully by the current ETS would provide a level playing field in terms of carbon pricing of fossil-fuelled road transport and rail with electric vehicles and electrified rail.

In principle it is difficult to argue for double EU regulation from an economic perspective, as for the same emissions two different parties would be obligated to reduce them, leading to potential inefficiencies. However, there is ample evidence that at least the short term price sensitivity in the buildings and transport sector is relatively low¹⁶⁵, hence prices either cannot overcome all barriers or might need to be very high to achieve the outcome, a risk which modelling and the resulting carbon price of €60/tCO₂ in CPRICE can only reflect to a certain extent.

In option ETS_2.2 the economic rationale for keeping the sectors newly covered in the EU ETS also in the scope of the ESR is to limit the carbon price impact risks for the industry sector by continuing to make sure that important non-price-sensitive abatement potentials would be addressed by the Member States. To be efficient, Member States would need to take into account the development of the EU ETS price and its impact on their domestic emissions in these sectors when specifying their policies.

Option ETS_3 creates an EU level carbon pricing instrument to facilitate the cost-efficient achievement of the ESR reductions, while acknowledging that there are externalities less amenable to be addressed by prices, for which targeted national policies (and/or some targeted intensification of EU wide energy efficiency and renewables policies) could be also economically useful.

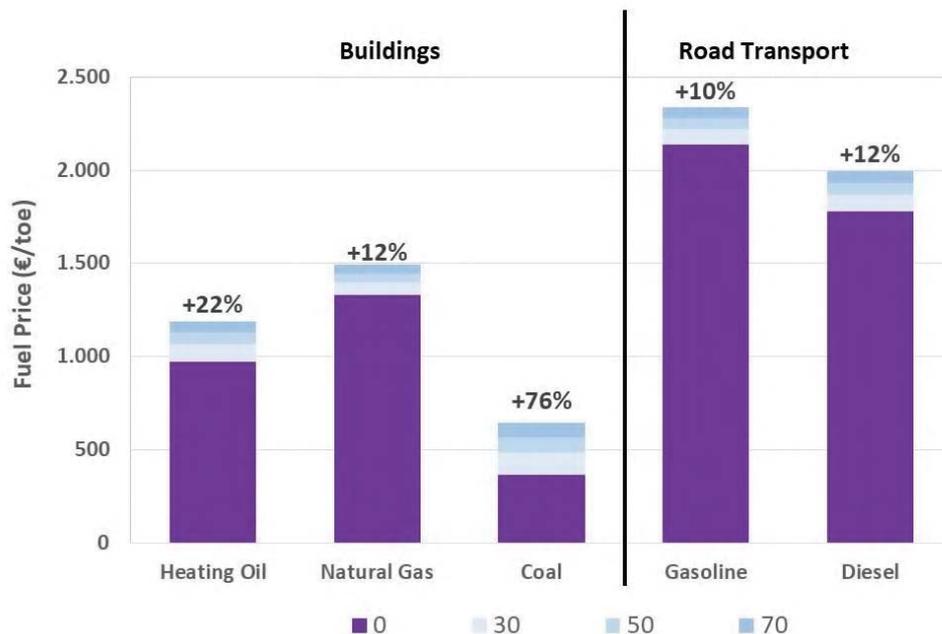
In option ETS_4, the variant with national carbon taxation has the economic advantage over emissions trading that prices are more predictable (subject to political interventions). However, emissions trading enables emission reductions to take place where least costly. In the few countries that have an effective carbon taxation for buildings and transport, carbon tax levels are often higher than current EU ETS prices.

Notably in the building sector, the introduction of the carbon pricing will have a material impact on end user prices. While this would exactly provide for the economic incentive to reduce emissions, it can also affect lower income households (see also section 6.5.2).

Figure 18 shows the sensitivity analysis for the effect of different carbon prices on fuel prices both in road transport and buildings in 2030.

¹⁶⁵ ICF et al. (forthcoming)

Figure 18: Average EU end user prices (2030 estimate)



Source: Enerdata, derived from EnerFuture (EnerBlue Scenario)

The cost efficiency of the ETS at achieving additional emissions abatement might be limited by the current heterogeneity of the national fuel tax landscape.

Auctioning is the default method for allocating allowances in the EU ETS, because it is the most economically efficient and simplest system and avoids windfall profits¹⁶⁶. Free allocation of allowances is only continued as a safeguard for sectors at a significant risk of carbon leakage. However, both the buildings and road transport sectors have relatively small or non-existing competitive pressure from outside the EU.

As discussed in section 6.4.2 auctioning puts a price on an externality, and allows recycling revenues. If used to reduce distorting taxes it decreases the overall economic impacts and can even spur growth. It can also be used to invest in precisely the low-carbon investment needed to decarbonise. This is line with the outcome of the consultation, where the largest share of respondents perceived that the revenue from carbon pricing should be used to finance green technologies and low-emission mobility infrastructure.¹⁶⁷

6.7.3 Social and distributional impacts of policy aspects

The results of the public consultation show that the social acceptability is often perceived by stakeholders as the largest challenge in relation to an extension of emissions trading to buildings and transport. The general social and distributional impacts of an increased ETS and ESR ambition and various scenarios are assessed in sections 6.4 and 6.5. Many of the policy aspects

¹⁶⁶ See e.g. Sijm, J., Neuhoff, K. and Chen, Y. (2006), *CO₂ cost pass through and windfall profits in the power sector*, Working Paper 0639 and EPRG Working Paper 0617.

¹⁶⁷ This was particularly selected by professional stakeholders.

depend on the details of policy proposals, thus only a few policy related considerations can be provided at this stage.

The impacts of a uniform carbon price for these sectors under options ETS_2 and ETS_3 are expected to vary across Member States, depending also on the way ETS auctioning revenues are distributed. Options ETS_2 and ETS_3 with ETS coverage of new sectors while maintaining them in the ESR could lead to additional distributional impacts between Member States depending on whether the national ESR targets would be significantly less or more stringent than ETS induced reductions.

The ESR has a relevant distributional impact on different Member States, mostly determined by the extent of gaps between emissions and targets¹⁶⁸. The scenarios indicate that additional emission reductions compared to the baseline under the current ESR scope (option ETS_1) are roughly equally distributed between higher income and lower income Member States.

6.7.4 *Administrative impacts*

Presently inventories of ESR emissions are based on the economy wide GHG reporting by the EU and its Member States to the UNFCCC from which the verified ETS emissions data are subtracted for each Member State. If emissions trading is extended to new sectors (options ETS_2 and ETS_3), it must be possible to measure and monitor emissions with high certainty and at reasonable cost and be able to attribute it to individual entities. The results of the public consultation show that administrative complexity and implementation of robust monitoring, reporting and verification systems are among the largest challenges identified by stakeholders in relation to an extension to new sectors.¹⁶⁹

An extension will require a new monitoring, reporting and verification system for the additional sectors. An extension to new sectors will trigger costs related to the setting in place and the operating of such a system, both for the regulated entities and public authorities, including in terms of IT infrastructure and human resources. Regulated entities' participation in the system would imply obtaining a permit, a registry account, putting in place a monitoring, reporting and verification system, obtaining and surrendering allowances. Public authorities would need to ensure the running of the system and compliance by regulated entities with its requirements.

Different competent authority structures in the EU ETS framework are encountered across Member States. In most Member States more than one competent authority is responsible for all activities of the ETS. For this reasons and due to possible coordination of monitoring and reporting with already existing requirements for the purpose of excise duty, it is not possible to give quantitative figures on the administrative costs incurred by regulators in the various Member States.

¹⁶⁸ See for details section 5.1 of the impact assessment of the Effort Sharing Regulation proposal, Commission SWD/2016/0247 final.

¹⁶⁹ The results of the public consultation show that the highest ranking in terms of challenges stemming from the administrative complexity and implementation, of a robust monitoring, reporting and verification system was given by consumer organisations (giving a ranking of 5 out of 5), followed by business associations (giving a ranking of 3.9 out of 5) and company/business organisations (ranking 3.8 out of 5). On average, public authorities ranked the challenge 3.7 out of 5. Hungary for example explicitly identified in its position paper accompanying its response to the public consultation the high administrative burden as one of the main problems of including the new sectors into the ETS.

Looking at the setting in place of the system, the option whereby the existing ETS is extended (option ETS_2) has the advantage that the use of the existing infrastructure may be more obvious. With regard to the costs associated with operating the system, options ETS_2 and ETS_3 would trigger recurring administrative costs and burden for regulated entities and public authorities. The cost of monitoring, reporting and verification in the current EU ETS has been estimated to represent about 70% of the total transaction costs and average MRV costs per entity have been estimated at around 22,000 €/year and 0.07 €/tCO₂¹⁷⁰. Furthermore, administrative costs include fees for the use of the registry which differ in the Member States¹⁷¹.

Because of the large number of small emitters (many of which are private persons) in the buildings and road transport sectors, a downstream approach such as in the current ETS whereby the emitters themselves are regulated does not seem feasible when extending emissions trading to the two sectors. An upstream approach whereby not the emitters themselves but entities further up the supply chain are regulated, can remedy the challenges associated with the large number of small emitters in the two sectors¹⁷². It must thereby be ensured that the chosen point of regulation is technically feasible (volumes can be monitored and reported, and end use known), that incentives to reduce emissions can be passed on to consumers, and that the administrative costs are proportional to the reduction effect.

An assessment against these elements shows that the regional distributors for gas¹⁷³, tax warehouses for oil¹⁷⁴ and distributors for coal could qualify for being upstream regulatory points. While there are more than 2,300 regional distributors for gas, the cost of identifying supply streams to buildings and filling stations is expected to be moderate. With respect to oil, the number of regulated entities would be high (there are approximately 7,000 tax warehouses) but the administrative costs for these entities would be moderate since they are already heavily regulated and an administrative quantity metering system for monitoring and reporting already exists for the purpose of excise duty. With respect to coal there would be a relatively high number of regulated entities (there are about 3,000 coal distributors). In comparison to the markets for oil and gas, the administrative impacts would be significantly higher since there would be many smaller regulated entities which have hardly been regulated up to now and which would need to establish reliable monitoring and reporting systems. Adequate measures would need to be put in place to mitigate this risk¹⁷⁵.

The above shows that with an extension of emissions trading to the two sectors as foreseen in options ETS_2 and ETS_3, the number of regulated entities would more than double compared to the current number of regulated entities under the EU ETS. However, it can be expected that the

¹⁷⁰ Monitoring, reporting and verifying emissions in the climate economy, 25 March 2015, V.Bellassen, N.Stephan, I.Cochran, J.-P.Chang, M.Deheza, G.Jacquier, M.Afriat, E.Alberola, C.Chiquet, R.Morel, C.Dimopoulos, I.Shishlov, C.Foucherot, A.Barker, R.Robinson. Nature Climate Change, Vol. 5, April 2015

¹⁷¹ https://ec.europa.eu/clima/policies/ets/registry_en#tab-0-1

¹⁷² For example, EDF have argued that a cost-efficient solution could be to place compliance obligations for small emissions sources higher up in the supply chain, e.g. on fuel suppliers and distributors.

¹⁷³ In principle also Transmission System Operators (TSO) could qualify as regulated entities, but given that TSOs are not the legal owner of the gas, possible legal obstacles at this level would need to be considered.

¹⁷⁴ Oil refineries could in principle also be chosen as point of regulation. In that case it would be necessary to also regulate imported and exported oil, which is not the case for tax warehouses.

¹⁷⁵ This could include for example requiring coal suppliers to monitor both coal they purchase and coal supplied to end-users in a mass-balance approach, and an assumption that in principle all coal that passes through a supplier is intended for end-users in the built environment, unless proven otherwise.

monitoring and reporting rules that would be adopted for the upstream regulated entities would be not more complex than in the current EU ETS system. In the new sectors, only sales of largely standardised fuels for combustion purposes would be monitored. The calculation of emissions could continue to rely on emission factors, as in the current system.

Adopting an upstream approach when extending emissions trading to the two sectors as foreseen in options ETS_2 and ETS_3 would lead to a hybrid system whereby some entities currently already covered under the EU ETS would continue to be regulated downstream. Any risk of double counting (e.g. upstream coverage of fuel being supplied to installations already covered by the EU ETS) or risk of loopholes (e.g. larger non-ETS gas consumers that do not purchase their gas from the distributors but have instead a direct connection to the gas TSO network) would need to be assessed appropriately.

If all fossil fuels emissions were included into an emissions trading system, it would not be necessary to differentiate between individual sectors. Still, the challenges coming from the combination of an upstream and downstream model (i.e. replacing the EU ETS with a new EU-wide-all-fossil-fuels upstream emissions trading system) and the risk of double counting would exist and need to be addressed. While a shift to a full upstream model may be seen to solve MRV issues, it would mean an overhaul of the ETS, which has proven to work well.

To the extent that the sectors are included into a national emissions trading system (option ETS_4), it is likely that precise coverage and regulation in the different Member States would differ leading to a heterogeneous design. However, the national systems could be more tailor-made in function of the existing situation in a Member State.

6.8 Climate and Energy Policy Architecture: ETS extension/carbon taxation and need to intensify energy and transport policies

The core scenarios analysed in section 6.2 to 6.5 represent in a stylised way interactions between climate and energy policy architectures, representing a more energy and transport policy driven policy mix to achieve the overall ambition (REG), a more carbon price driven policy mix (CPRICE) and a policy mix combining stronger carbon pricing with intensified energy and transport policies (MIX) with a variant intensifying non-CO₂ policies (MIX-nonCO₂). Following the more detailed analysis of options to strengthen the climate policy architecture (section 6.7) and to intensify renewables and energy efficiency policies (section 6.6) the aim of this section is to analyse the interaction of these policy options, illustrated for a GHG emission reduction of -55%.

Policy interactions are already manifold between existing climate and energy policies. A particular focus of this section is on the building and transport sectors, as they are covered by the horizontal legislation on GHG emissions (Effort Sharing Regulation), on renewables (Renewable Energy Directive), energy efficiency (Energy Efficiency Directive, Energy Performance of Buildings Directive) and fuel infrastructure (Alternative Fuels Infrastructure Directive), but currently, except for aviation, not by the horizontal EU carbon pricing instrument, the EU Emissions Trading System. In addition, several pieces of sector specific EU legislation apply. The policy scenarios clearly show that ambitious policies are needed to achieve the overall climate ambition increase. The focus of this section is mainly on new policy interactions between intensified renewable energy and energy efficiency and transport policies and possible new EU carbon pricing policies through coverage by emissions trading or mandated carbon taxation in two sectors: buildings/residential and services heating and road transport.

The strengthening of existing renewable, energy efficiency and transport policies builds on intensifying and reinforcing existing interactions between specific policies on energy efficiency and specific policies fostering renewable energy, in line with the Energy Efficiency First principle. To succeed it is of utmost importance to exploit synergies and seek consistency of the reviews of the Renewable Energy Directive, the Energy Efficiency Directive, the Energy Performance of Buildings Directive and the EU Ecodesign and Energy Labelling Framework. The REG scenario reflects this reinforcement with, in 2030, a 0.7 to 1.1 percentage points (p.p.) further final energy consumption reduction than in the other scenarios, as well as a 0.3 to 1.2 p.p. higher renewables share compared to the other scenarios. This synergetic effect comes with a drop of the total amount of direct renewable final energy consumed compared to baseline (BSL, of -3%) and the other two scenarios, which increase 1-2% compared to BSL. This is also partly due to the higher rate of electricity use in final energy consumption compared to baseline (but similar as in MIX and CPRICE) which contributes to both renewables and energy efficiency. The absolute amount of electricity used in final energy is 2% lower than in baseline and 1-2% lower than in the scenarios with carbon pricing.

The success of this policy mix would also depend on exploiting synergies with other relevant policies, essential to deliver on a more integrated energy system as put forward by the Commission in its recent strategy¹⁷⁶, such as the review of the TEN-E regulation, sustainable product policy, circular economy and biodiversity strategies, etc. As it is composed of a large number of individual policy elements to address specific barriers, the detailed policy interactions and challenges can only be analysed once these policy elements are more clearly specified. An example of such interaction is that the impact of very strong policies targeting only the building envelope would lower the energy demand and reduce the need to also look for renewable solutions to meet the remaining demand, and vice-versa, policies targeting only renewables deployment could limit the incentives to improve energy efficiency, as savings of energy coming primarily from renewable sources might seem less attractive. Limited information and lack of highly skilled workers regarding the availability of options regarding heating requirements could lead to sub-optimal decisions prior to or during a renovation, which could be either non-renewable based or result in over-sized solutions.

There are clear interactions of the described policy mix with the EU Emissions Trading System, as it lowers the additional carbon price incentive needed to reduce CO₂ emissions in the power, industry, electric heating and district heating sectors. The MIX scenario reflects this policy interaction with intensified policies on energy efficiency and renewable energy resulting in significantly lower carbon prices in 2030 of €44/tCO₂ instead of €60/tCO₂ in 2030. This would be an important feature of limiting the impact on traditional ETS sectors in case of scope expansion in the EU ETS. Interactions with the Effort Sharing Regulation are different in nature. The binding national emission reduction targets under the latter have mainly the function of a safeguard that the intended energy-related emission reductions through the specific policies are achieved, incentivising Member States to effectively implement policies and mitigate distributional effects between Member States, while ensuring that also in the ESR sectors not addressed by renewables and efficiency policies (currently around 40% and in 2030 around 45% of ESR emissions) sufficient emission reduction policies are implemented at the national level.

¹⁷⁶ COM(2020) 299 final

Very strong EU energy efficiency, renewable and transport policies can also lower the need for national emission reductions in other effort sharing sectors.

Extending carbon pricing by means of trading emissions or carbon taxation to other energy use sectors such as buildings and transports can lead to significant interactions with the described specific policies. The provided financial incentive for low emitting energy uses and financial penalty for high emitting energy uses can positively influence market diffusion of minimum energy performance requirements for buildings, CO₂ emission standards for vehicles and eco-design standards e.g. for boilers and water heaters. It can also drive the quicker diffusion of the use of renewable energy in heating and transport and hence help achieving the objectives and obligations under the Renewable Energy Directive. Such effects would strongly depend on the level of the carbon price. As regards buildings renovations, carbon price alone is however expected to have a limited impact on deep renovations. These interactions are reflected in the changes to baseline in the CPRICE scenario, reducing final energy consumption in ESR sectors by 5%, increasing RES H&C shares by 6 p.p. and renewable final energy demand by 12%. ETS or carbon taxation is one instrument to provide the additional economic incentives for energy efficiency and renewable energy investments.

Stronger incentives for electrifying demand which put the same price tag on fossil fuel energy use in buildings and transport as in the ETS lead to 2% higher electricity share in final demand than in baseline. A drawback from an environmental perspective is a stronger incentive to use bioenergy, the use of which compared to baseline would increase by 5%, however 1 p.p. less than in REG. A drawback from a social perspective are the higher energy prices for consumers. A policy example where such policy interactions can be illustrated is the ambitious Swedish carbon taxation¹⁷⁷. Hence sustainability safeguards for bioenergy and redistributive elements as accompanying measures would gain further importance.

There are some interaction differences which depend on or link with the choice of the carbon pricing instrument, ETS or carbon taxation¹⁷⁸. The EU is competent to set up an EU ETS and has experience with it, while taxation is largely a Member State prerogative, with the EU only setting minimum tax levels to safeguard the internal market, and also this only if all MS agree. There is an emerging national experience (see discussion of the German example) and extra-EU experiences with emissions trading systems including buildings and/or transport. Electrification, which already in BSL increases from less than 25% now to more than 30% in 2030, expands its

¹⁷⁷ Sweden has been one of the pioneers in carbon pricing, with a carbon tax in place since 1991, nowadays at EUR 110/tCO₂ for heating and transport fuels, adding to energy taxation. For heating, sustainable biofuels are not taxed. Similarly, biofuels in the transport sector must be classed as sustainable in order to be eligible for tax deductions. In addition, there are several other policy measures in place, including an emission reduction obligation for suppliers of gasoline and diesel to decrease emissions by continuously increasing the share of biofuels in the fuel-mix. As a result of the carbon tax and complementary policies, in particular buildings emissions were reduced. Also, the decrease in road transport emissions seen since 2007 is mainly attributed to the fact that road transport is operated with an increasing proportion of biofuels. On energy prices, Swedes have been generally willing to contribute and have a positive attitude towards societal climate initiatives. However, public opposition against increasing fuel prices has been growing, mainly in rural areas (ICF et al., forthcoming).

¹⁷⁸ Today, energy taxation leads to implicit carbon prices, but does typically not address the carbon content explicitly, hence distorting the direct emission reduction incentive. Highly divergent national rates are applied in combination with a wide range of tax exemptions and reductions, which can, de facto, be seen as forms of fossil fuel subsidies, which are not in line with the objectives of the European Green Deal. Provided that they are well-designed, carbon taxes could nevertheless have a price signal potential.

coverage and potentially shifting emissions from effort sharing sectors, including buildings and transport, to the existing ETS sectors¹⁷⁹. The more a sector is using electricity, the stronger the argument to put electricity and fossil fuels used on equal footing in terms of carbon pricing, as is currently the case for industrial combustion, combined heat and power (CHP) and district heating. As the picture is very different for buildings and transport, the details are covered in the sector specific annex 9.8.

As analysed under option ETS_4 in section 6.7, beyond this economic argument, an ETS with its fixed emission quantity provides also certainty to achieve emission reductions and hence the EU GHG target than a carbon tax and is robust towards rebound effects. However, there is a risk that given the historically rather low elasticity of demand the necessary carbon price increases might be higher than modelled. This could be the case if accompanying policies to address other market barriers are not there or less effective, or national governments feel responsible anymore. The analysis of the option ETS_2.2 and ETS_3 in parallel to an ETS coverage the ESR should be maintained tackle this issue in more detail. Carbon taxation has target uncertainty but the economic advantage that prices are more predictable.

Although Member States have gained extensive experience with setting up an EU ETS between 2008 and 2012, there are also higher administrative costs to set up an ETS where it cannot build on existing taxation rules, as analysed in detail in the previous sections. This also illustrates that the policy details matter greatly, not only in this respect. But also carbon taxation can come at an administrative costs and economic inefficiencies, either through many exemptions and differentiations, as observed in energy taxation, or through different national systems which impact the internal market. And it should not be forgotten that also the Renewable Energy and Energy Efficiency Directive include obligations on companies which lead to administrative costs.

Based on considerations above, there are a number of arguments in favour of combining elements from both policy mix approaches, which is already the case in several Member States. Economic incentives are important, as e.g., the increase in building and transport emissions following the decrease of oil and stabilisation of gas prices in the second half of the last decade indicates. But so are specific measures targeted to address either specific barriers or addressing cost-effective untapped potentials related to specific alternatives to fossil fuel use. There is no doubt that specific renewables, efficiency and transport policies will continue to be of crucial importance, such as to address the split-incentive dilemma in building renovation, increase coherence of energy infrastructure planning, supportive licensing procedures, consistent of greener certification procedures or ensuring better available information for energy consumers. Also in countries with emissions trading covering buildings and transport sectors, the ETS in these sectors is typically seen as part of a broader policy mix. This is also reflected in stakeholder views. Most stakeholders see carbon pricing in buildings and transport as complementary to other sector specific policies (64%, 1009), while few favour a regulatory only or carbon pricing only approach (14% each). Stakeholders favour for both sectors that the carbon price should be set at EU level (77% for transport, 64% for buildings).

Such combinations require sector specific discussions. Specific illustrations for the buildings/heating and transport sectors are provided in annex 9.8.

¹⁷⁹ The latter are already impacted today due to actions in the non-ETS sectors

6.9 Implications of ETS policy architecture for addressing carbon leakage risks

Industrial emissions reductions stagnated between 2013 and 2017, a period with low carbon prices and a large surplus of EU ETS allowances on the market. This trend reversed in 2018 with the introduction of the Market Stability Reserve. The assessment confirms GHG reduction potential remains in the industrial sector, with the MIX-50 reducing CO₂ emissions in industry¹⁸⁰ by 21% in 2030 compared to 2015, while for REG, MIX, CPRICE and ALLBNK reductions range from -23% to -26%. Other assessments based on the ETS benchmarking data and a bottom up study confirm this magnitude of reduction potential (see annex 9.4.2.7 for more details)

Overall industrial sectors would be reducing less than most other sectors (see section 6.2, Table 6) in the period 2015 – 2030, largely based on existing technologies. There is thus a risk of a significant gap between these short and mid-term reductions and the need for the uptake of new innovative technologies to decarbonise by 2050. Demonstrating them at scale is crucial in the coming decade.

Using macro-economic modelling tools impacts were assessed of increased climate ambition on energy intensive industrial sectors. The results indicate that without increased global action, increasing climate ambition in the EU typically results in a negative impact for the energy intensive sectors. Impacts are significantly limited with free allocation. Sectoral production can be positively impacted if the climate policy and any associated carbon revenues are seen as boosting investment and economic development (see section 6.4.2, Table 16 and annex 9.5.3, Table 49). None of the modelling assumed any additional measures to protect against carbon leakage¹⁸¹.

Free allocation in the ETS is determined by benchmark values and from 2021 periodically updated production data¹⁸². There is a limit to the total free allocation, set at 43% of the total cap for stationary sources with a further 3% buffer. If this cap is reduced with increased climate ambition, then there is a higher likelihood that free allocation based on benchmarks will overshoot this available limit. If this occurs, under the current rules of the ETS, a Cross Sectoral Correction Factor would apply for the remaining years in the period 2021-2030, lowering all free allocation to respect this overall limit.

A stylised assessment was made of the likelihood of the application of such a downward correction of free allocation if the cap in the ETS (current scope) was set to achieve by 2030 the

¹⁸⁰ Including refineries

¹⁸¹ Carbon border adjustment measures will be subject to a specific impact assessment to be prepared by the European Commission by 2021.

¹⁸² The benchmark values are set using the historical applicable benchmark in the period 2013-2020 and applying an annual reduction rate. This annual reduction rate is determined by the historical progress of the benchmark, i.e. the 10% best installations, and is limited to a rate of at least 0.2% annually and at most 1.6% annually. This rate is applied on the benchmark value of the year 2007/2008 and thus can lead to a benchmark that is at least 3% and at most 24% more stringent in the period 2021-2025 compared to the benchmark applied in the period 2013-2021. For this assessment estimates have been calculated for the period 2021 – 2025 using preliminary data. The benchmark values to be applied for the period 2026 – 2030 will be based on the emission efficiency of installations in years 2021 and 2022. As this data is not available yet, a conservative approach has been taken using no further improvements for this assessment.

projected emissions of the MIX-50, MIX and ALLBNK scenario (see Figure 17)¹⁸³. An ETS cap in line with a 50% GHG reductions scenario (MIX-50) would not be expected to require a correction. If the caps are set in line with the higher projected GHG reductions of the 55% (MIX and ALLBNK), then it would still be likely that no correction applies for a cap that only changes the LRF in 2026. Instead with an approach that would rebase the cap for stationary installations in 2026, then a correction may apply in 2030 for a cap in line with MIX, and in 2029 and 2030 for a cap in line with ALLBNK.

To be noted that these calculations are subject to uncertainties, including the estimated future production levels of industrial sectors, the future benchmarks which will only be decided by end of 2020, general modelling assumptions as well as the methodology of how to update the LRF.

An extension of the scope of the ETS would in principle increase the total amount of allowances (see also section 6.7), and with the current ETS structure (57% auction share and 43% free allocation share with a 3% of the cap free allocation buffer sourced from the auction share), the application of a correction of free allocation is even less likely. In case there would be less free allocation to some sectors, linked to a carbon border adjustment mechanism, there would in principle be less likelihood of a cross sectorial correction factor being applied.

The Covid-19 crisis has affected industrial production in a major way and it is as yet unclear what the long-term impact will be on industrial production and restructuring. This is not yet taken into account in this assessment.

6.10 The role of the LULUCF policy architecture in achieving increased ambition in GHG removals

This section assesses the options as presented in section 5.2.2.5. Further detail can also be found in annex 9.9. The current LULUCF legislation creates an incentive for Member States to keep the sink from deteriorating compared to a benchmark of historic land management practices. The key benefit of this approach is that it integrates the very diverse geography of the EU, where each Member State has a specific profile of land use, climate conditions, etc. through a common bottom-up approach, and safeguards the LULUCF sink from deteriorating beyond what existing practice would result in. For instance, the current approach takes account of increasing forest harvesting rates well beyond historical practice.

Section 6.2.3 gave an overview of how the LULUCF sink can develop over the next decade following a set of different scenarios. Table 27 gives an overview how the different LULUCF scenarios as assessed in section 6.2.3 can generate LULUCF credits under the current LULUCF regulation. In the worst case situation, if Member States do not achieve any improvement in the accounted sink and simply meet the No Debit scenario, generating no LULUCF credits, this could result in a deterioration of the sink to 225 MtCO₂-eq by 2030, notably with ageing and harvesting in forests negatively impacting the sink profile.

¹⁸³ The exercise took into account data from the European Transaction Log (EUTL), data received as part of the NIMs as well as the production projections assumed in the baseline scenario with the PRIMES model.

Incentives exist in the current LULUCF regulation to improve on this, notably the flexibility of the LULUCF sector to the ESR with maximum of 262 Mt over the period 2021-30¹⁸⁴. Given that this flexibility to the ESR is fixed per Member State and cannot be traded between Member States, it is unlikely that the full 262 Mt flexibility will be used over the 10 year period. As such the incentive signal provided by the current climate policy architecture to take increased action in the LULUCF sector is limited and rather in-line with the FRL scenario than scenarios achieving a higher sink by 2030.

These higher sink scenarios (MIX and notably LULUCF+) would have to rely on other drivers to achieve an improved sink than those of the current climate policy architecture, which for instance does not provide any direct incentives for farmers and foresters to take action on the ground. Other policies such as the CAP strategic plans or the Biodiversity or forthcoming Forest strategy could provide some additional incentives.

If targets in the ESR/ETS would be set following options as presented in section 6.7.1, Table 26, and assuming inclusion of the LULUCF sink in the total GHG target in a conservative manner (see section 6.1.1¹⁸⁵), and at the same time achieving by 2030 a LULUCF sink as high as estimated in the LULUCF-MIX and LULUCF+ scenario would allow the EU to enhance its overall ambition beyond the 50% or 55% GHG target¹⁸⁶. For instance the REG, MIX and CPRICE scenario would achieve GHG reductions¹⁸⁷ of 56.5% and 57.5%, respectively, with a sink as in the LULUCF-MIX and LULUCF+ scenarios.

Table 27: LULUCF credits generation estimates by 2030 (MtCO₂-eq)

	No Debit	FRL	LULUCF-MIX	LULUCF+
Forest Land*	0	26	64	84
Agricultural Land	0	6	6	21
Wetlands**	0	0	0	10
Total Credits	0	32	70	115
Reported sink	-225	-257	-295	-340

Note: *Forest land includes managed forest land, afforested land and deforested land; ** the inclusion of managed wetlands in national LULUCF accounts is currently optional but this should be revised for the period 2026-2030

Source: UNFCCC inventories, GLOBIOM model

Option LULUCF_2.1: Increase the flexibility of LULUCF credits towards the ESR and/or ETS

This option would allow for increased flexibility from the LULUCF sector to the ESR, and potentially to the ETS. Assuming that costs and challenges are higher in ESR sectors to achieve

¹⁸⁴ For the existing 2030 framework this flexibility was assessed as representing up to around a quarter of the total additional reduction required in the non-ETS compared to baseline projected. For more information see SWD(2016) 249 final

¹⁸⁵ As a contribution to achieve 50% or 55% GHG emission reductions by 2030, it is assumed in Table 4 that the LULUCF sink will achieve 225 million tonnes removals by 2030.

¹⁸⁶ Including LULUCF, including intra EU aviation and navigation.

¹⁸⁷ Including LULUCF, including intra EU aviation and navigation.

the targets, this would result in increased incentives for Member States to take effective action in the LULUCF sector.

Possibilities for increased action in the LULUCF sector are not evenly distributed across the Union, and Member States will similarly have different challenges in their ESR targets. Policy design thus needs to decide how increased use of LULUCF credits are distributed across Member States, which will require additional analysis taking into account distributional impacts.

Policy design could furthermore improve incentives such that action will be taken where it is most efficient in the LULUCF sector. Relaxing trading restrictions – notably in how LULUCF credits can be used in the ESR sector across Member States – would compensate for the unbalanced distribution of sink potential between Member States and deliver access to more cost-efficient solutions to mitigation.

A further step to improve incentives would be to certify enhanced levels of carbon stored in the LULUCF sink at the level of private land ownership, and allow this to be traded for compliance by Member States in the LULUCF regulation and the ESR flexibility. Methods to avoid double counting and to address the carbon storage reversal risk would be required, as would reporting methods to consolidate the increased sink into Member State reporting of greenhouse gas inventories. This will require further methodological research and the Commission is exploring the development of such a regulatory framework for certification of carbon removals.

Increasing the LULUCF flexibility by allowing the use of sink credits for ESR/ETS compliance would allow the combined ESR and ETS to deliver fewer GHG reductions. For instance, if targets in the ESR/ETS were to be set following the options as presented in Table 26, and if LULUCF credits would be generated at the level of the LULUCF-MIX and LULUCF+ scenarios, GHG emission reductions excluding LULUCF could be decreased to 51.5% and 50.5% respectively, while still meeting a 55% GHG target including LULUCF.

This type of flexibility would clearly be a strong driver for moderating overall compliance costs of achieving 55% GHG while still providing improved incentives for the EU sink to be enhanced, with a view to achieving net zero GHG by 2050.

Option LULUCF_2.2: Strengthening of LULUCF regulation – moving towards a greater direct contribution from the sector

This option would strengthen the requirements for an increase of the level of LULUCF sink to be achieved in the LULUCF regulation itself, rather than create increased demand for LULUCF credits.

Approaches to this end could include the cancellation of a number of LULUCF credits before they can be used for trade between Member States in the LULUCF sector or towards flexibility with the ESR, or to change accounting rules making the no debit rule in the LULUCF Regulation more stringent.

If LULUCF accounting rules would be tightened, it raises the question of how to do so. The single largest sector is forest land. Defining an additional “net credit” effort on top of the current Forest Reference Level (FRL) approach, would duplicate – at least – the process and discussions leading to the FRL setting. Further complications would emerge if this were to be indexed differently from the FRL – for example, indexed with GDP, per capita income, or carbon removal potential. Setting such an approach would thus need further careful analysis taking into account distributional impacts.

More practically, and given the predominance of the forest sink, a significant increase in the LULUCF credit threshold could be achieved through a simplification of the FRL setting process. The most common alternative international standard applied is the accounting of the sink against a historical reporting period (so-called ‘net-net’ accounting), such as 2000-2009. Compliance with such an approach would already generate an increase in sink over the current Forest Reference Levels in the LULUCF regulation by around -73 MtCO₂-eq per year. Moving to such an accounting benchmark based on performance in base years or periods, instead of basing it on projections, is not subject to technical interpretation and would simplify the current process.

This approach is already required¹⁸⁸ to be assessed by the Commission in 2027 (and 2032) for all the sub-sectors in LULUCF, as part of the overall compliance check. Extension of this as a “backstop” clause could already provide a collective EU enhancement of the sink, without specifically addressing each Member State with a new target negotiation.

Cancellation of LULUCF credits is a less strong incentive than tightening of the accounting rules for additional action in the Member States. Tightening accounting rules, with current full flexibility from the ESR to the LULUCF sector, may still not necessarily increase the sink if Member States would find it less difficult to achieve emission reductions beyond target in the ESR.

Increased stringency in the accounting rules in the LULUCF Regulation, that would lead to a higher sink than the No Debit scenario, would permit reduced stringency in the ESR/ETS targets as presented in Table 26, while combined still achieving the overall 50% or 55% GHG target.

If instead the increased stringency in the accounting rules in the LULUCF Regulation were to be introduced without reducing the ESR/ETS targets as included in Table 26, this would potentially result in GHG reduction beyond the overall 50% or 55% GHG target.

Similarly, an alternative approach that would cancel LULUCF credits without changing the ESR/ETS targets, could lead to an overachievement of the overall 50% or 55% GHG target. The legislation governing the two sectors would thus need to be revised, and reciprocal adaptations of the current LULUCF flexibility under the ESR would be needed.

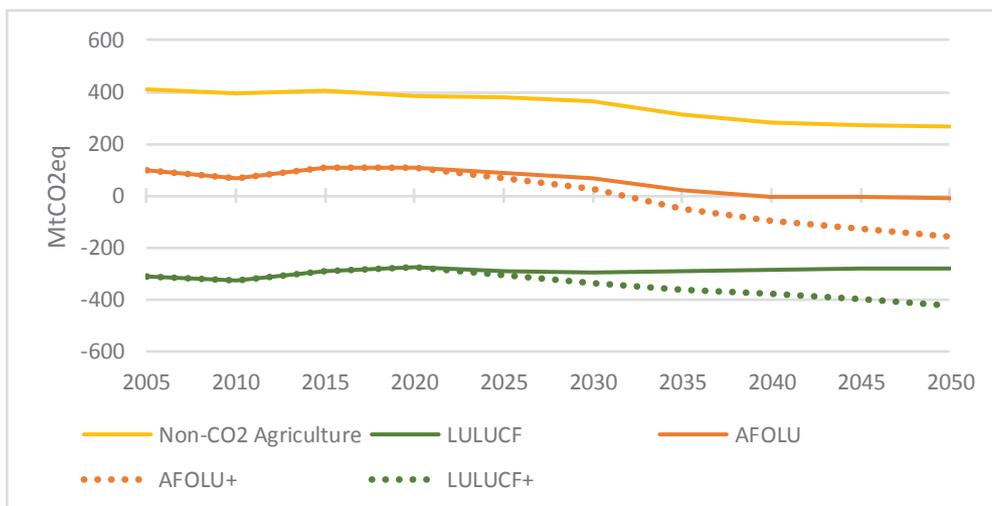
Option LULUCF_2.3: Merging Non-CO₂ emissions from agriculture with LULUCF removals: creating an AFOLU (or bio economy) sector with a separate target

In the case that the sectors covered by the ESR would be considerably changed, e.g. all energy CO₂ emissions would be included in the EU ETS and taken out of the scope of the ESR (option ETS_2.1, see section 6.7), agricultural emissions would become relatively isolated. The non-ETS sectors – including LULUCF – would in effect be an extended form of the IPCC’s combined Agriculture, Forestry and Other Land Use (AFOLU) configuration¹⁸⁹. Given that biomass related emissions in other sectors are conceptually set to zero, the removal and emissions scope of these combined sectors also corresponds to the biomass biogenic related emissions of the bio economy.

¹⁸⁸ Reg (EU) 2018/841 Art 14(3)

¹⁸⁹ See 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4. Agriculture, Forestry, and Other Land Use, <https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html>

Figure 19: The potential impact of additional incentives on evolving AFOLU emissions in the MIX scenario until 2050



Note: The AFOLU line is the sum of the non-CO₂ Agriculture emissions as in the MIX scenario and the LULUCF sink projected without additional incentives to enhance the LULUCF sink in MIX. AFOLU+ includes additional action to enhance the LULUCF sink (LULUCF+). Climate neutrality will require a LULUCF sink that is at least maintained or enhanced (see also analysis Long Term Strategy, 1.5LIFE and 1.5TECH scenarios)

Source: GLOBIOM model, GAINS model

This relatively closed accounting configuration could perhaps ease the design of efficient and effective policies in this sector – for example through the CAP – and better align them with implementation actions. The key question is how this merger on its own would achieve a more substantial land sink in the medium to long term.

One simplification could be that the accounting framework would more readily become a net sum of the *reported* values in these sectors, with likely a streamlined set of accounting rules to address specific land issues (permanence, variability, natural disturbances).

With agricultural non-CO₂ emissions in 2025 and 2030 still higher than the net LULUCF sink, a target other than the current “no debit rule” for the LULUCF sector would have to be established for the sector as a whole that, together with the extended ETS, meets the overall economy wide target of 50% or 55% and that assures the correct and complete accounting of biomass emissions. Figure 19 indicates that these reported removals and emissions would need to achieve “no debits” around 2035 and to further increase sink (i.e., deliver “net credits”) beyond.

This accounting design would frame the reduction actions to within the agriculture non-CO₂ sector and available enhancements in the LULUCF sector, unless combined with trading with the ETS. Overall the approach raises the question as to how this can be organised at the EU level, and likely would require national target setting approaches and require a similar detailed analysis taking into account differences in geographic distribution of removals and emissions including (additionally) those of non-CO₂ emissions.

National targets would provide for clear incentives to improve the matching of other national policies (primarily CAP implementation and specific associated land mitigation actions) and thus increase the information requirements. This can be important to drive action at the individual

level of farmers and foresters themselves. Raising ambition in the sector inevitably relies on engaging and facilitating these actors, directly.

While the AFOLU bio economy related sectors can potentially move relatively quickly towards a balanced emissions-removals profile at the EU level, putting effective incentives on the ground to enhance the sink - and subsequently compensate other sectors with residual fossil emissions - will have its own challenges to implement. This underlines that the sector could still benefit from a link to the extended ETS, to provide for additional incentives beyond the AFOLU collection of sectors.

In all options, the capture of the sink, mainly in forests, by agricultural emissions would mean that other economic options for the use of biomass products (timber, pulp and paper, fabrics, advanced biofuels, etc.) would face new competition. Furthermore, preserving the carbon stock in the sector (increasing the sink through avoiding emissions rather than improved silvicultural management) could be valorised, with potential co-benefits for biological diversity and other ecological functions of standing forests. Such a design needs to be counter-balanced with the risk of significant change in the sourcing of materials for the bio economy, that may drive imports forward and reducing rural economic and social benefits, and thus will also need further consideration.

7 HOW WILL IMPACTS BE MONITORED AND EVALUATED?

EU climate and energy legislation provides for a comprehensive framework to track progress towards meeting EU targets. While specific pieces of legislation¹⁹⁰ contain the relevant substantive requirements, the overarching framework is provided by the Climate Law and the detailed integrated monitoring and reporting framework is provided by the Regulation on the Governance of the Energy Union and Climate Action.

The Climate Law, as proposed by the Commission in March 2020, will enshrine in EU law the objective of climate neutrality in the EU by 2050. It includes measures to keep track of progress and adjust EU actions accordingly. Progress will be reviewed every five years, in line with the global stock take exercise under the Paris Agreement. The climate law also includes a process to include the 2030 target in the law itself based on this Impact Assessment.

The Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action has established an integrated energy and climate planning, monitoring and reporting framework, which allows monitoring progress towards the climate and energy targets in line with the transparency requirements of the Paris Agreement.

Under the Governance Regulation, Member States develop integrated national energy and climate plans. The first plans cover the five dimensions of the Energy Union for the period 2021-2030. Member States will report biennially on the progress made in implementing the plans, including on climate, renewables and energy efficiency. The Commission assesses whether these plans add up to collectively meet EU binding targets and, if need be, propose further measures to ensure plans are fully implemented and targets achieved. The Commission will monitor the progress in the EU as a whole, in particular as part of the annual State of the Energy Union report and biennially assess the progress made. By 2023/24 the Member States will provide draft and final updates of the plans, in line with the 5-yearly ambition cycle of the Paris Agreement.

As parties to the UNFCCC and the Paris Agreement, the EU and the Member States are required to report to the UN annually on their greenhouse gas emissions ('greenhouse gas inventories') and regularly on their climate policies and measures and progress towards the nationally determined contributions.

Under the EU's own internal reporting rules set in the Governance Regulation on the basis of internationally agreed obligations, Member States monitor greenhouse gas emissions on their territories and report on emissions of seven greenhouse gases from all sectors: energy, industrial processes, land use, land use change & forestry (LULUCF), waste, agriculture, etc. as well as on projections, policies & measures to cut such emissions. This includes the necessary elements to track progress of the implementation of EU climate legislation, as well as of the EU's international commitments under the UNFCCC and Paris Agreement.

In addition the Governance Regulation sets out that, the Commission has to produce an annual report on progress on the EU contribution under the Paris Agreement and on achieving the ESR and LULUCF Regulation obligations as well as the 2030 targets for climate and energy. At the same time – every autumn – the European Environment Agency also publishes a more detailed report on trends and projections in GHG emissions, renewable energy and energy efficiency.

¹⁹⁰ In particular the ETS Directive, Effort Sharing Regulation, LULUCF Regulation, Regulation on CO₂ for cars, Renewables Directive, Energy Efficiency Directive

Data collected in the context of Regulation (EU) 2018/1999 is being made publicly accessible on an e-platform, including to date the final NECPs and long-term strategies. Also Indicators for monitoring progress towards Energy Union objectives are published¹⁹¹.

Furthermore, some specific pieces of legislation contain provisions on monitoring actual developments. In fact, regarding greenhouse gas emissions, monitoring rules are often the first regulation to be put into place since one obviously needs to measure the starting point; this is how historically the regulation of greenhouse gas emissions has developed. This is illustrated most recently by Regulation (EU) 2015/757 on the monitoring, reporting and verification of CO₂ emissions from maritime transport.

Any change to the existing climate and energy monitoring framework that would be required in the context of the policy measures proposed in the 2030 Climate Target Plan will be assessed as part of the specific legislative revisions to be proposed by June 2021. Further background on the assessment of options can be found in annex 9.9.

¹⁹¹ https://ec.europa.eu/energy/data-analysis/energy-union-indicators/scoreboard_en?redir=1

8 COMPARING OPTIONS AND CONCLUSIONS

This Impact Assessment looked into the impacts of (1) policy options to the increase climate ambition to 50% to 55% greenhouse gas (GHG) reductions by 2030 compared to 1990 in order to achieve a more balanced path to net zero GHG emissions by 2050 as well as (2) policy options related to the climate and energy policy architecture to implement such increased ambition.

These policy options were assessed using sectoral as well as macro-economic modelling tools covering all GHG emitting sectors, assessing *combinations* of policy options related to ambition as well as policies deployed – in the form of scenarios. Furthermore also qualitative assessments were made, notably regarding elements of the policy architecture. This section summarises the main findings. Key modelling results for 2030 comparing quantitative results for different levels of ambitions and across different policy scenarios are summarised in Table 28 at the end of this section.

GHG ambition and sectoral impacts in the energy system

By contributing currently over 75% of total GHG emissions¹⁹² in the EU, the energy sector will be at the forefront of the efforts towards an increased climate ambition by 2030. An increase in climate ambition translates into an increased ambition of the energy transition by 2030, well beyond the current energy targets for renewables deployment (RES) and energy efficiency (EE). 50% GHG ambition goes hand in hand with ca. 35% RES share as well as 34.5% final energy savings and 37% primary energy savings. 55% GHG reduction sees ca. 38%-40% renewable energy share by 2030. 2030 final and primary energy savings increase to 36-37% and 39-41% respectively (see Table 28).

Likewise, a large majority of public consultation replies endorsed the most ambitious options for climate, renewables and energy efficiency. 77% of the respondents to the public consultation expressed the view that the GHG target should be increased to at least 55%, nearly 70% expressed the view that consequently the current renewable energy target should be increased to a share higher than 40% and more than 60% of respondents preferred a target greater than 40% of (primary and final) energy efficiency savings. Though replies of notably business associations were more equally distributed across ambition levels.

The scenarios with comparable GHG target scope see higher EE and RES ambition for the scenario that focuses on regulatory measures. The scenario which exhibits the highest ambition for RES and EE assumes the widest scope of the GHG target, including next to extra EU aviation also emissions from the maritime sector. This shows that next to the level of GHG ambition and policy architecture, also the scope of the GHG target impacts the necessary ambition of the energy system.

As a consequence of the increased energy savings and RES deployment the clean energy transition accelerates and the use of fossil fuels decreases with long-lasting effects until mid-century. Progression by 2030 is more significant for the options with 55% GHG target than with a 50% GHG target. Additional advantages can be measured in savings in the fossil fuel import bills, which are as large as 0.1 to 0.2% of GDP in 2030 across scenarios, with higher benefits linked to increased climate ambition and more pronounced energy savings.

¹⁹² Including the non-CO₂ emissions from the energy system.

In a 2050 perspective, the performance of 55% and 50% GHG scenarios is very similar in terms of RES shares and absolute RES amounts underlining the central role of RES in achieving climate neutrality. In fact, the scenario achieving 50% GHG reductions (MIX-50) has to catch up with 55% GHG scenarios in terms of RES deployment already shortly after 2030 in order to be on the path to climate neutrality. 55% GHG reduction scenarios have thus the advantage of scaling up the RES deployment more progressively. Scenarios that rely more on energy efficiency need slightly lower amounts of decarbonised synthetic fuels by 2050 in order to reach climate neutrality.

This Impact Assessment points to a strong role of further electrification of the economy to achieve the increased climate target. Electrification is confirmed as a key avenue for energy system integration and thus cost-effective decarbonisation in line with the Energy System Integration Strategy¹⁹³. New fuels such as hydrogen appear in all scenarios in significant quantities only post-2030 but are crucial in this time-frame to achieve climate neutrality as also mapped out in the Hydrogen Strategy¹⁹⁴.

For all policy scenarios modelled, highest GHG reductions (compared to 2015) in the energy system are achieved in the power (through uptake of renewables) and buildings sectors (through fuel switch alone or combined with renovations).

The findings for transport and industry are slightly different. These sectors remain more difficult to decarbonise and the key challenge is to ensure that advanced vehicles and fuels and industry sector technologies (e.g. hydrogen) are demonstrated at scale during this decade to deliver increased reductions after 2030.

This leads to important sectoral policy conclusions. The assessment pointed out, for instance, that scenarios that focus on carbon pricing do not incentivise renovation that much, while they do incentivise fuel switching. Similarly, the carbon price alone will at the levels estimated for this decade - not sufficiently trigger the demonstration and deployment of clean technologies both in the transport (vehicles and fuels) and industry sector (e.g. hydrogen) at scale during this decade to deliver increased GHG reductions after 2030.

From a broader perspective, accelerating the energy transition will help to modernise the whole EU economy creating opportunities for clean energy technology leadership and gaining competitive advantage on the world markets thanks to the large domestic market. These effects will happen faster with a more ambitious 2030 GHG target. Finally, bigger savings achieved on the fossil fuel bill thanks to increased climate ambition can be invested in the further modernisation of the EU economy.

Sectoral impacts related to non-CO₂ and the land use sector

Non-CO₂ emissions represent around 20% of the EU GHG emissions and a significant mitigation potential remains there. Options assessed differentiate the contribution of this mitigation option and demonstrate that its increased mobilisation (in MIX-nonCO₂ variant) can reduce the need for actions in the energy sector, for instance, impacting RES deployment by almost a percentage point (final energy efficiency performance, however, remaining unaffected). While these emissions are covered under the ESR, targeted sectoral policies play a crucial role. This is shown

¹⁹³ COM(2020) 299 final

¹⁹⁴ COM(2020) 301 final

by the large reductions already in the baseline induced by, for instance, ambitious existing waste legislation and F-gas regulation reducing notably emissions in heating and cooling. This confirms the need of additional action, for instance, in the context of the Methane Strategy.

The LULUCF sink has decreased in the past 5 years due to natural hazards and a market driven increase in the rate of forest harvest. This underlines risks for the magnitude of the sink while it is of crucial importance to achieve net zero GHG emissions by 2050 as discussed in the in-depth analysis accompanying “Clean Planet for All” Communication. This assessment fully includes the LULUCF sink when appraising the achievement of 50% to 55% GHG ambition. It does so in a conservative manner, i.e. by including the sink at a level corresponding to the no-debit rule under the LULUCF Regulation which requires no backsliding compared to how the sink would evolve under current practices. Options were assessed how the sink would be impacted by increasing bioenergy needs or policies that expand the sink. If increased bioenergy needs are met through expanding the sustainable production of mainly woody energy crops and sustainable forest management, impacts on the projected sink are expected to be limited.

Environmental impacts

Regarding environmental impacts, the option to reduce 55% GHG emissions clearly outperforms the option to reduce 50% and not only in terms of GHG savings. It achieves larger co-benefits compared to Baseline on issues such as health, air pollution control costs and reduced environmental degradation. For instance, 55% GHG scenarios see air pollution reduced by 60% compared to 2015. Replies to the public consultation saw lower pollution and related improved health and wellbeing as main tangible benefits linked to increased climate ambition.

Synergies and risks related to the biodiversity strategy exist. The implementation of the Biodiversity Strategy is coherent with significant GHG reductions in the sector. While biomass needs for the energy system do increase, these are limited up to 2030 but increase afterwards. Producing this increased biomass supply through sustainable forestry, biodiverse rich afforestation and an overall reasonable deployment of sustainable energy crops could reconcile climate and biodiversity objectives.

Economic and social impacts

As shown in Table 28, energy system costs that combine investments and expenditures for energy purchases increase to ca. 11% of GDP (excluding carbon pricing payments¹⁹⁵ and disutilities) for both the 50% and 55% GHG ambition levels. They do not vary significantly between the different options assessed. Excluding carbon pricing payments and disutility costs, scenarios based on carbon pricing see a marginally lower system cost increase than scenarios based on increased regulatory intervention. Including carbon pricing payments and disutility, costs increase in a more pronounced manner and in this case the scenario based on increased regulatory intervention becomes the lowest cost scenario. After 2030, differences in energy system costs excluding carbon pricing payments and disutility costs shrink further between scenarios.

While energy purchase expenditures decline in all scenarios, the energy system costs increase is driven strongly by investments increases. The assessment sees annual investments, including transport, increase in the period 2021-2030 compared to the period 2011-2020 with EUR 312

¹⁹⁵ Representing notably auctioning in an emission trading system.

billion to achieve 50% GHG reduction. For 55% GHG reductions, the annual investments increase by EUR 326 billion in a scenario mainly based on carbon pricing and to EU 377 billion in a scenario based on increased regulatory intervention mainly due to increased investments in demand side sectors (e.g. the residential sector). A scenario that combines regulatory intervention with carbon prices sees an increase by EUR 356 billion. Initial investments will be repaid over time through reduced energy purchase expenditure, but mobilising the necessary scale of finance will be a significant policy challenge.

Revenues from carbon pricing are as high as € 75 bn in a scenario chiefly based on carbon pricing and as low as € 16 bn in a scenario based on increased regulatory intervention by 2030. Increased use of carbon pricing poses both opportunities and challenges. Increased revenues of carbon pricing can be recycled in the economy and improve macro-economic outcomes of increased climate ambition. If applied in non-ETS sectors and used to lower some distortionary taxes (such as on labour or income) or support green investments, macro-economic impacts¹⁹⁶ of increased climate ambition are in the range of -0.27% to +0.50% of GDP compared to baseline (assuming no global action). Without revenue recycling the impacts range from -0.38% to +0.19% of GDP (assuming no global action). Similar results are found for employment, with no additional carbon pricing revenue recycling leading to worse employment impacts (range of -0.26% to +0.01%) than additional carbon pricing with recycling (range +0.02% to +0.20%) which can actually increase employment compared to the baseline, confirming the double dividend of greening taxation.

Overall, macro-economic impacts are limited, confirming that reducing GHG emissions by as much as 50% to 55% by 2030 if done efficiently is not a risk to the EU economy. Economic projections also indicate that the impact of higher climate ambition on GDP is positive if one takes into account that the economy has unused capacity, which is the case under current circumstances where a major potential output gap has opened in the EU economy due to the COVID-19 crisis.

But differences exist and in some sectors value added and employment will be negatively affected, notably in fossil fuel extraction and, to a lesser extent, in some industrial sectors, particularly if no comparable global action is undertaken. These are sectors with actually relatively highly skilled workforce underlining the need for reskilling.

Different levels of greenhouse gas reduction ambition and different policy instruments used to achieve it, affect energy system costs in contrasted manners.

The share of energy expenditures in household income is set to increase from approximately 7% in 2015 to 7.5% - 7.9% in the policy scenarios by 2030 (see Table 28) with the highest impact in the highest ambition scenario applying carbon pricing, though differences remain limited. Scenarios based on carbon pricing increase more fuels prices, while scenarios based on regulatory intervention have a relatively more significant impact on housing prices due to increased investment needs related to the building. These changes will not affect all the European citizens equally: households in the lower income deciles tend to spend more on energy services and might lack the capital needed to invest in energy efficiency.

¹⁹⁶ Results for scenarios with globally fragmented action

Changes in relative prices due to higher climate ambition are expected to negatively impact the welfare of lower-income or lower-expenditure households more than that of households at the top of the distribution. Assuming unchanged consumption patterns over time, the negative impact for the lowest deciles amounts to around 2% of income or expenditure for the lowest decile for a scenario that applies both regulatory policies and carbon pricing. This impact can be mitigated and reversed if revenue recycling of carbon pricing is applied with a focus on low income households. Addressing distributional impacts will thus require appropriate policies (e.g. increased transfer payments, subsidies for energy efficiency measures or progressive energy tax rates).

The COVID-19 crisis has not significantly altered the investments needed to reach the decarbonisation target, but likely worsened the conditions for such investments to take place, at least without strong policy intervention. A preliminary assessment of the COVID-19 crisis projects 2020 energy CO₂ emissions to drop by 11% compared to the no-COVID Baseline, but no comparable reduction can be expected in the investments needed in the coming decade, neither during nor after economic recovery, to achieve the increased climate ambition. In essence, the crisis today does not reduce the amount of structural investments needed. The role of policy intervention that delivers a recovery package focussed on green investments is of key importance.

Policy architecture

The scenario assessment also provides insights in possible impacts of different policy architectures. Keeping the existing regulatory architecture intact (scenario REG) while delivering on the increased climate ambition would require significant intensification of energy efficiency, renewable energy, transport and other policies. Conversely, extending the scope of carbon pricing and emission trading to transport and buildings, and not increasing the ambition of energy and transport policies would also be possible but would see 2030 carbon prices rising sharply to €60/tCO₂ (scenario CPRICE) or above (scenario ALLBNK).

The option that combines both additional regulatory ambition with increased use of carbon pricing (scenario MIX) combines several strong points of the two alternative policy approaches while moderating their respective disadvantages. MIX sees energy system costs increase, both with and without carbon pricing payments and disutility, but each time it is closer to the lower end of the range established by REG and CPRICE. It raises significant auctioning revenues for recycling (€ 55 bn) and thus would allow for more favourable macro-economic results if smart revenue recycling policies would be applied. It increases carbon prices (€44/tCO₂) significantly less than CPRICE also making policies to moderate negative impacts more manageable than if one would apply only additional carbon pricing.

While respondents to the public consultation see the ETS Directive as requiring a higher ambition increase than the Effort Sharing Regulation, the responses in the public consultation also emphasised the need for complementary regulatory policies to accompany any carbon pricing policy.

Intensification of renewables, energy efficiency and transport policies

Higher GHG ambition, unless driven principally by carbon pricing (as illustrated by the CPRICE scenario), will require increased ambition of the energy-efficiency and renewables policy framework.

Both the modelling results as well as replies to the public consultation indicate that carbon pricing alone in buildings and transport might not be sufficient to address non-economic and

market barriers. Such persistent barriers would prevent decarbonisation efforts that could be economically viable and would result in unnecessary high carbon prices.

In the buildings sector, the rate and depth of renovations as well as the deployment of renewable heating and cooling solutions in the baseline is well below what is necessary to reach the higher GHG ambition. Likewise, in the transport sector, decarbonisation meets with several challenges and strengthening of policies will be necessary to address specifically: further reduction of CO₂ emissions from vehicles, availability of infrastructure for zero-emission vehicles, increased penetration of renewable and low carbon fuels particularly in aviation and maritime sector and greater use of more sustainable transport modes and multi-modal solutions (supported by investments in the TEN-T core and comprehensive network), digitalisation, smart traffic and mobility management, road pricing and incentives driving behavioural changes. Also the effort in the industrial sector both in terms fuel switch and energy efficiency is not sufficient. Importantly, without starting the demonstration and deployment at scale of renewable and low-carbon technologies already by 2030, the transport and industry sectors will not be able to make the required shifts after 2030 needed to achieve climate neutrality by 2050.

To deliver the increased ambition of the energy efficiency, renewables and transport policy framework at the EU level as required for an increased climate target, existing policies will have to be intensified. Furthermore, more targeted or new measures will have to be implemented in specific areas to remove the current barriers and market failures and thus pave the way for the most cost-effective decarbonisation of the energy system.

Consequently, this assessment looks into the type of instruments already present in the current energy efficiency, renewables and transport legislation that could be strengthened or see their scope extended, as well as into the types of instruments that should be deployed to meet the specific challenges. It outlines interactions between different policies. The assessment concludes that regulatory measures of the existing legal framework for energy efficiency, renewables and transport would need to be properly implemented, intensified and work together with actions arising from the new Commission initiatives such as the Strategy for Energy System Integration¹⁹⁷, the Hydrogen Strategy¹⁹⁸ as well as the upcoming Offshore Renewable Energy Strategy, the Renovation Wave and the Sustainable and Smart Mobility Strategy. Finally, the coherent rollout of all relevant enabling policies, including those that unlock financing at the scale needed, would be critical for an integrated, efficient, resilient and renewables-based energy system ensuring affordable, sustainable and secure energy during the transition towards climate neutrality.

Enhanced carbon pricing and the role of the Effort Sharing Regulation (ESR)

The scenario assessment confirms that expanding carbon pricing through emissions trading or carbon taxation in an appropriate policy context would provide for harmonised economic incentives to reduce emissions at the same time raising revenue for governments and providing resources for climate action or for addressing social and distributional concerns. If implemented through an emissions trading system, the cap would ensure achievement of the GHG reduction objective.

¹⁹⁷ COM(2020) 299 final

¹⁹⁸ COM(2020) 301 final

One possible avenue to extend the role of carbon pricing would be to expand the scope of the existing EU Emissions Trading System (ETS) to fossil fuel use in non-ETS sectors, such as buildings, and road and maritime transport. Other avenues could be: a separate EU-wide emissions trading system for new sectors, national emissions trading systems for specific sectors, or carbon taxation.

If the scope of the ETS were to be extended to fossil fuel use in both buildings and road transport, the projected necessary emission decrease for this extended ETS scope (-56% in MIX scenario compared to 2005) would be lower than the one reflecting the current scope (-63% in REG scenario). If no such extension of scope is applied, the resulting emission decrease in the sectors covered by the Effort Sharing Regulation (ESR) would be larger with -39% in REG scenario than in the case of extended ETS and a downsized ESR (-34% excluding buildings and road transport to -30% excluding all energy CO₂ in the MIX scenario), as the sectors that would be transferred to the ETS reduce comparably more than remaining ESR sectors.

To reduce the risk of excessively high carbon prices with an extension of ETS scope, any expansion of ETS into the buildings and road transport could benefit from a strong complementary regulatory framework that delivers more energy efficiency, renewables and transport decarbonisation. If these policies are not reinforced at the EU level, it could be considered to maintain the scope of sectors covered in the Effort Sharing Regulation even with the extension of the ETS scope to ensure that Member States maintain ambitious policies.

Tools to enhance carbon pricing other than the inclusion in the current ETS would have similar benefits and challenges. One particular benefit could be that they would allow for learning by doing, setting up gradually the required regulatory framework and administrative capacity. One particular challenge is that carbon taxation or national emission trading systems would not deliver the overall EU GHG reduction with certainty and thus would require somehow a continuation of the ESR in its present form.

The Impact Assessment also looked at the administrative impacts of covering additional sectors such as buildings and/or road transport by an emission trading system, and concludes that this is feasible and that this has both advantages and challenges. One aspect to take into account in this context is that limiting any upstream emissions trading system (with compliance obligations applied at the level of tax warehouses, gas and coal distributors instead of end users) to a subset of sectors would complicate its administration considerably.

The scenario assessment also confirmed that in case of no global action (that is comparable to EU action), free allocation could still contribute to preventing carbon leakage – with lower impacts for energy intensive industrial sectors in case of free allocation than with auctioning. Presently under the ETS up to 43% of total allowances (with an additional 3% buffer) can be used for free allocation to industry sectors using a benchmark approach. If free allocation based on the benchmark approach would breach the maximum amount of 43% of the overall ETS cap plus a 3% buffer, a cross sectoral correction factor would be applied reducing free allocation to industry and increasing the risk of carbon leakage. This assessment looked into how likely it would be that increased ambition in line with 50% and 55% GHG reductions, together with the recently reviewed benchmarking methodology, would trigger such a cross sectoral correction factor. The conclusion is that this would be rather unlikely for a 50% reduction and could occur to a significant extent only with 55% reductions and a rebasing of the cap towards the end of the period 2021-2030. Expansion of ETS scope is likely to reduce further this risk.

Role of the LULUCF sink

Ensuring that the LULUCF sink is maintained and even enhanced by 2050 is crucial to balance any remaining emissions in the economy with carbon dioxide removals and to achieve net zero GHG emissions. This contrasts with an evolving trend of decreasing overall EU forest growth, increasing harvesting in some Member States and damaging impacts of natural hazards (e.g. fires and pests).

As the possibilities for increased action in the LULUCF sector are not evenly distributed, any policy needs to set incentives in an efficient manner. Climate legislation could play a role in this respect. Increasing flexibility between the LULUCF sector and ESR or even the ETS could provide for enhanced incentives, and could allow for a corresponding reduction in ambition increase in those sectors. A different target than the current “no debit rule” for the LULUCF can also be established to incentivise Member States to take more action but would require the development of a new methodology to set the appropriate level of ambition per Member State. To ensure action is effectively taken direct incentives for farmers and foresters merit to be explored. Extending the ETS to a significant part of current energy emissions in the ESR and downsizing the ESR correspondingly would result in an ESR with a very large share of agriculture non-CO₂ emissions. In such a case, it makes sense to look at both sectors together and, in the scenarios modelled in this Impact Assessment, the combined agriculture and forestry and land use sectors (AFOLU) are projected to achieve net-zero GHG emissions around 2035 in trajectories towards a climate neutral EU by 2050.

Preferred options

This Impact Assessment has compared the impact of increased climate ambition in the range of 50% to 55% GHG reductions, including the impact of expanding the scope of the GHG target next to aviation also to the maritime sector. It has assessed how this ambition relates to overall energy efficiency and renewable energy levels of ambition. As this section demonstrates, it allows for a multi-criteria assessment of the options to achieve a more balanced pathway towards climate neutrality by 2050. The Impact Assessment confirms that an ambition increase within the range of 50% to 55% GHG reductions is possible, in a responsible manner and deliver sustainable economic growth (see Figure 20 below for a representation of such a pathway achieving 55% GHG reductions).

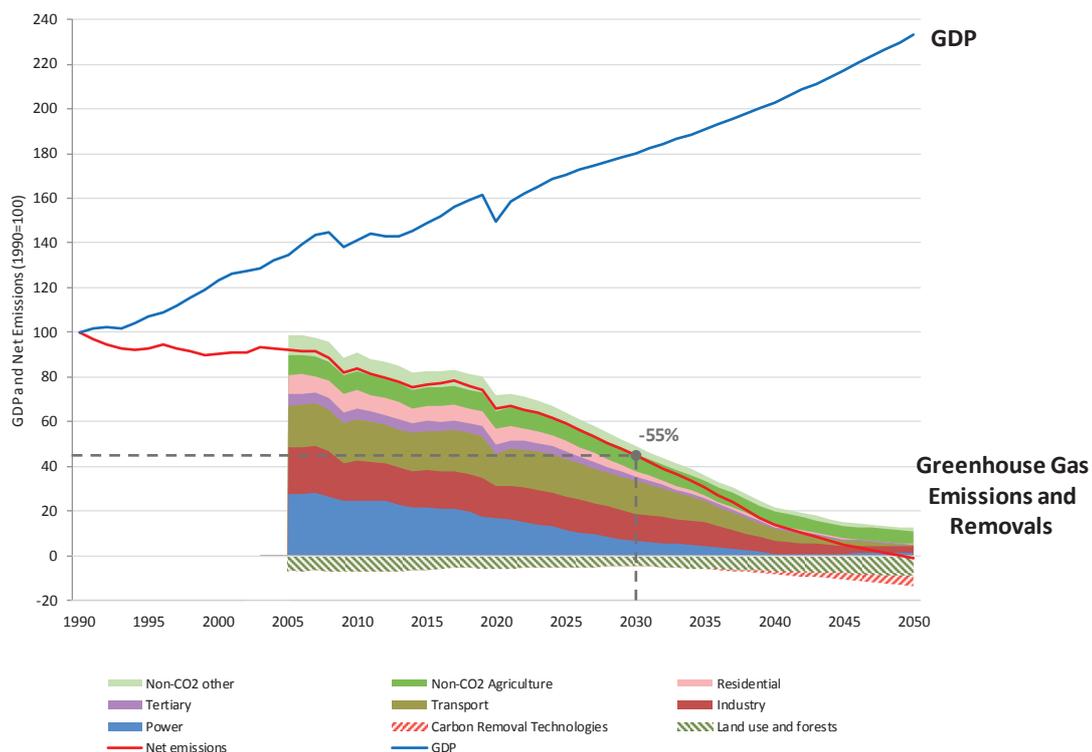
The 55% GHG reduction option would spur a faster clean energy transition by raising the 2030 ambition to around 38.5 % share of renewables and to around 36% improvement in final energy consumption; all accelerating the related modernisation of the EU economy. It would bring clear environmental advantages, not limited to reduced contributions of the EU to climate change. The economic risks of increasing ambition to 55% GHG are limited, while such level of ambition would increase investor certainty on the pathway towards carbon neutrality.

The biggest challenge is related to how to considerably step up investments in the clean energy transition. This challenge has become larger with the COVID-19 crisis, stressing the immediate need for a focus on green recovery.

The Impact Assessment confirms that a step up of climate ambition will require a review of many EU policy instruments to deliver it. It has assessed the interaction of a complex set of options in terms of different policy architectures and levels of intensity to which they could be activated. The Impact Assessment clarifies the understanding of the impacts of various options, and sees particularly benefits in deploying a broad mix of policy instruments, including extending carbon pricing and increased energy and transport regulatory policy ambition, and clearly suggests that

no single policy instrument would be capable of achieving all the objectives considered in the assessment alone.

Figure 20: A pathway to climate neutrality



Note: Figure based on a stylised representation of historic GHG and GDP data and PRIMES, GLOBIOM, GAINS 5 yearly point estimates for the MIX scenario.

Source: Adapted from EEA GHG data viewer (as in Figure 35), EUROSTAT GDP data and PRIMES, GLOBIOM, GAINS models

Table 28: Overview of key modelling results

EU27 2030		BSL	MIX-50	REG	MIX	MIX nonCO2 variant	CPRICE	ALLBNK
GHG reductions (incl LULUCF and intra EU aviation and maritime) vs 1990		-46.9%	-51.0%	-55.0%	-55.0%	-55.1%	-55.0%	-57.9%
RES share		32,0%	35,1%	38,7%	38,4%	37,5%	37,9%	40,4%
PEC energy savings		-34.2%	-36.8%	-40.1%	-39.7%	-39.3%	-39.2%	-40.6%
FEC energy savings		-32.4%	-34.4%	-36.6%	-35.9%	-35.9%	-35.5%	-36.7%
Environmental impacts								
GHG emissions reduction in EU ETS stationary sectors vs 2005		-55%	-60%	-65%	-65%	-64%	-65%	-69%
GHG emissions reduction in current ESR Sectors vs 2005		-32%	-36%	-39%	-39%	-40%	-39%	-41%
Air pollution (for BSL vs 2015, for other scenarios vs BSL 2030) ¹⁹⁹		-56.5%	-3.4%	n/a	-8.4%	n/a	n/a	-10.1%
Reduced pollution control costs vs BSL (billion €)			2.36	n/a	4.87	n/a	n/a	6.30
Energy system impacts								
GIC (Mtoe)		1 201	1 158	1 103	1 109	1 116	1 117	1 094
- Solid fossil fuels		8%	7%	6%	5%	6%	5%	4%
- Oil		33%	33%	33%	34%	34%	34%	34%
- Natural gas		22%	20%	20%	20%	20%	20%	20%
- Nuclear		13%	13%	11%	11%	12%	11%	11%
- Renewables		24%	26%	30%	30%	29%	29%	31%
Final Energy Demand (Mtoe)		795.5	771.0	743.4	753.0	752.9	757.6	743.7

¹⁹⁹ These are air pollution impacts adding up the emissions of NO_x, SO₂ and PM_{2.5}. They have not been assessed for every scenario but for representative scenarios of particular greenhouse gas ambition level.

RES share in heating & cooling	33%	37%	40%	40%	39%	39%	39%	42%
RES share in electricity	55%	58%	64%	65%	63%	64%	64%	67%
RES share in transport	18%	20%	26%	24%	23%	22%	22%	26%
Economic and social impacts	BSL	MIX-50	REG	MIX	<i>MIX nonCO2 variant</i>	CPRICE	ALLBNK	
System costs excl carbon pricing and disutilities ave. annual (2021-30) as % of GDP	10.7%	10.9%	11.1%	11.0%	10.9%	10.9%	11.0%	11.0%
System costs incl carbon pricing and disutilities ave. annual (2021-30) as % of GDP	10.9%	11.3%	11.4%	11.4%	11.4%	11.6%	11.7%	11.7%
Investment expenditures (incl transport) ave. annual (2021-30) vs (2011-20)	263	312	377	356	351	326	371	371
ETS price (€/ton)	32	36	32	44	44	60	65	65
Import dependency (%)	54%	53%	53%	53%	53%	53%	52%	52%
Fossil fuels import bill as % of GDP	1.9%	1.8%	1.7%	1.8%	1.8%	1.8%	1.7%	1.7%
Primary Energy Intensity (toe/M€'13)	76.8	74.1	70.5	70.9	71.4	71.5	70.0	70.0
Energy- expenditures (excl transport) of households as % of household income	7.2%	7.5%	7.6%	7.7%	7.6%	7.8%	7.9%	7.9%
GDP impacts*	JRC-GEM-E3 range: -0.70% to -0.02% E3ME range: +0.12% to +0.55% QUEST range: -0.29% to +0.13%							
Employment impacts*	JRC-GEM-E3 range: -0.43% to +0.6% E3ME range: +0.01% to +0.23% QUEST range: -0.09% to +0.45%							
*Ranges depend on the level of ambition in the EU (50% or 55%), the level of ambition in the rest of the world (fragmented action or effort compatible with climate neutrality by 2050), scope extension of carbon pricing and model-specific assumptions on the use of carbon revenue, labour market imperfections or energy intensive industries firm behaviour.								

GLOSSARY

Term or acronym	Meaning or definition
AFOLU	EU Agriculture, Forestry and Land Use
BACS	Building Automation and Control Systems
Biofuels	Biofuels are liquid or gaseous transport fuels such as biodiesel and bioethanol which are made from biomass.
Biofuels (conventional)	Biofuels are produced from food and feed crops.
Biofuels (advanced)	Biofuels produced from a positive list of feedstock (mostly wastes and residues) set out in Part A of Annex IX of Directive (EU) 2018/2001.
BOE	Barrels of oil equivalent
CAP	Common Agricultural Policy
CAPRI (model)	Common Agricultural Policy Regionalised Impact model: a global multi-country agricultural sector model, supporting decision making related to the Common Agricultural Policy and environmental policy.
CCS	Carbon Capture and Storage: a set of technologies aimed at capturing, transporting, and storing CO ₂ emitted from power plants and industrial facilities. The goal of CCS is to prevent CO ₂ from reaching the atmosphere, by storing it in suitable underground geological formations.
CCU	Carbon Capture and Utilisation: the process of capturing carbon dioxide (CO ₂) to be recycled for further usage.
CEDEFOP	European Centre for the Development of Vocational Training
CEF	Connecting Europe Facility: an EU funding instrument to promote growth, jobs and competitiveness through targeted infrastructure investment at European level.
CGE	Computable General Equilibrium: a family of economic models.
CHP	Combined Heat and Power: a combined heat and power unit is an installation in which energy released from fuel combustion is partly used for generating electrical energy and partly for supplying heat for various purposes.

CH ₄	CH ₄ is the chemical formula for methane, a greenhouse gas. CH ₄ is used as shorthand to refer to methane.
CO ₂ -eq	CO ₂ -eq stands for carbon dioxide-equivalent. This is a measure used to compare quantities of different greenhouse gases in a common unit on the basis of their global warming potential over a given time period.
COP	Conference of the Parties: decision-making body of the United Nations Framework Convention on Climate Change (see UNFCCC)
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
COVID-19	Global pandemic caused by a coronavirus unknown before the outbreak began in Wuhan, China, in December 2019.
DG ECFIN	Directorate General Economic and Financial Affairs
E3ME	Energy-Environment-Economy Macro-Econometric Model: a model for macroeconomic analysis.
ECB	European Central Bank
EE	Energy Efficiency
EEA	European Environment Agency
EED	Energy Efficiency Directive: Directive 2012/27/EU and amending Directive 2018/2002/EU
E-fuels	Liquid fuels produced on the basis of hydrogen obtained from electricity via electrolysis
E-gas	Gaseous fuels produced on the basis of hydrogen obtained from electricity via electrolysis
EIB	European Investment Bank
EII	Energy intensive industries
Energy system costs	Sum of fixed and variable costs for the energy system, including investments, operations and maintenance, as well as fuels.
EPBD	Energy performance of buildings directive: Directive 2010/31/EU and amending Directive 2018/844/EU
EPC	Energy Performance Certificates (see also EPBD)

ERDF	European Regional Development Fund
ESOS	Energy savings obligation scheme
ESR	Effort Sharing Regulation: Regulation 2018/842/EU
ETD	Energy Taxation Directive: Directive 2003/96/EC
EU ETS	European Union Emissions Trading System as established under Directive 2003/87/EC
EU, EU27	European Union with 27 Member States since 1 February 2020
EU28	European Union with 28 Member States from 1 July 2013 to 31 January 2020
EUTL	European Union Transaction Log: central transaction log, run by the European Commission, which checks, records and authorises all transactions between accounts in the Union Registry (see also EU ETS, NIMs)
FAO	Food and Agriculture Organization
FEC	Final Energy Consumption: all energy supplied to industry, transport, households, services and agriculture, excluding deliveries to the energy transformation sector and the energy industries themselves (see also GIC, PEC)
F-GASES	Fluorinated greenhouse gases, including hydrofluorocarbons (HFCs) perfluorocarbons (PFCs) and sulphur hexafluoride (SF ₆).
FRL	Forest Reference Level (see also LULUCF)
G20	Group of 20: international forum for the governments and central bank governors from 19 countries and the European Union (EU) ²⁰⁰ .
GAINS (model)	Greenhouse gas and Air Pollution Information and Simulation
GDP	Gross Domestic Product
GEM-E3-FIT (model)	General Equilibrium Model for Energy Economy Environment interactions: a computable general equilibrium model, version operated by E3Modelling, a company (see also JRC-GEM-E3).

²⁰⁰ The Group of Twenty (G20) is a forum made up of the European Union and 19 countries: Argentina, Australia, Brazil, Canada, China, Germany, France, India, Indonesia, Italy, Japan, Mexico, Russia, Saudi Arabia, South Africa, South Korea, Turkey, the United Kingdom and the United States.

GHG	Greenhouse Gas
GIC	Gross Inland Consumption: the quantity of energy necessary to satisfy inland consumption of the geographical entity under consideration, i.e. the Total Energy Supply, plus the international aviation (see also FEC, PEC).
GLOBIOM (model)	Global Biosphere Management Model: a model for land use of agriculture, bioenergy, and forestry.
GtCO ₂	Giga tonnes of CO ₂
GW	Gigawatt
HBS	Household Budget Surveys: national surveys of households focusing mainly on consumption expenditure.
Hydrogen	A feedstock for industrial processes and energy carrier that can be produced through a variety of processes from fossil fuels or electricity via electrolysis.
Hydrogen (GHG neutral)	Hydrogen from GHG neutral sources, mainly through electrolysis using GHG neutral electricity. This includes renewable hydrogen, which is from renewable electricity via electrolysis.
Hydrogen (Clean, Renewable)	Hydrogen, which is from renewable electricity via electrolysis.
IA	Impact assessment
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
ICT	Information and Communication Technology
IEA	International Energy Agency
IIASA	International Institute for Applied Systems Analysis
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
JRC	Joint Research Centre of the European Commission
JRC-GEM-E3	General Equilibrium Model for Energy Economy Environment interactions: a computable general equilibrium model, version

	operated by the JRC (see also GEM-E3-FIT)
LRF	Linear Reduction Factor (see also ETS)
LTS	COM(2018) 773: A Clean Planet for all - A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy
LULUCF	Land Use, Land-Use Change, and Forestry
LULUCF regulation	Regulation on emissions and absorptions of the LULUCF sector: Regulation (EU) 2018/841
MFF	Multiannual Financial Framework
MRV	Monitoring, Reporting and Verification scheme implemented in Regulation (EU) 2015/757 on the monitoring, reporting and verification of CO ₂ emissions from maritime transport
MSR	Market Stability Reserve (see also EU ETS)
MtCO ₂	Million tonnes of CO ₂
Mtoe	Million tonnes of oil equivalent
MWh	Megawatt hour
N ₂ O	N ₂ O is the chemical formula for nitrous oxide, a greenhouse gas. N ₂ O is used as shorthand to refer to nitrous oxide.
NDC	Nationally Determined Contributions (as required by the Paris Agreement)
NECP	National Energy And Climate Plan
NGEU	Next Generation EU
NIMs	National Implementation Measures, submitted under Article 11 of the ETS Directive (see also ETS)
NOX	Nitrogen Oxide(s)
'No Debit rule'	Under EU legislation adopted in May 2018, EU Member States have to ensure that greenhouse gas emissions from land use, land use change or forestry are offset by at least an equivalent removal of CO ₂ from the atmosphere in the period 2021 to 2030.
NZEB	Near Zero Energy Building

OECD	Organisation for Economic Co-operation and Development
PDF (indicator)	Potentially Disappeared Fraction of global species
PEC	Primary Energy Consumption: Gross Inland Consumption (GIC) minus the energy included in the final non-energy consumption (see also, FEC, GIC)
PHS	Pumped Hydropower Storage
PM 2.5	Particulate Matter with a diameter of 2.5 micrometre or less
POLES-JRC (model)	Prospective Outlook on Long-term Energy Systems: a global long-term energy system model operated by the JRC
PRIMES (model)	Price-Induced Market Equilibrium System: an energy system model for the European Union.
PRIMES-TREMOVE (model)	Model for the transport sector, integrated in the PRIMES model.
PtG	Power to gas: technologies for the production of E-gases (see also E-gases)
PtL	Power to liquids: technologies for the production of E-fuels (see also E-fuels)
QUEST / E-QUEST (model)	Quarterly Economic Simulation Tool: a global macroeconomic model used by the Directorate General for Economic and Financial Affairs (DG ECFIN)
RED / RED II	Renewable Energy Directives 2009/28/EC and 2018/2001/EU
RES	Renewable Energy Sources
RES-E	Renewable Energy Sources in the generation of Electricity
RES-H&C	Renewable Energy Sources in Heating and Cooling
RES-T	Renewable Energy Sources in Transport
RFNBO	Renewable Fuels of Non-Biological Origin: liquid or gaseous fuels which are used in the transport sector other than biofuels or biogas, the energy content of which is derived from renewable sources other than biomass
SET-Plan	EU Strategic Energy Technology Plan
Sink	Any process, activity or mechanism that removes a greenhouse gas, an aerosol, or a precursor to a greenhouse gas from the atmosphere

SME	Small and Medium-sized Enterprise
Synthetic fuels and gases	See E-fuels, E-gases
TEN-E	Trans-European Networks for Energy
TEN-T	Trans-European Networks for Transport
TFEU	Treaty on the Functioning of the European Union
TWh	Terawatt-hour
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
VAT	Value Added Tax
ZELV	Zero and low emissions vehicles
ZEV	Zero emissions vehicles

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