INCREASING THE EU’S 2030 EMISSIONS REDUCTION TARGET

How to cut EU GHG emissions by 55% or 65% by 2030

JUNE 2020
BACKGROUND TO THIS WORK:  
NET-ZERO SCENARIOS DEVELOPED  
WITH THE CTI 2050 ROADMAP TOOL

This work builds upon the CTI 2050 Roadmap Tool that was used for the ECF’s report on Net-Zero in 2050.1 That report, published in September 2018, provided a perspective on the feasibility and the implications of reaching net-zero greenhouse gas (GHG) emissions for the EU by 2050 at the latest. It described the key changes required to achieve significant GHG reductions and highlighted potential net-zero trajectories and their implications in terms of both costs and co-benefits.

The same model is used here to test possible trajectories for cutting the EU’s GHG emissions by -55% or -65% by 2030 compared with 1990 levels (without taking removals through land use, land-use change and forestry (LULUCF) and emissions from bunkers into account in order to align with the current EU targets debate). This report shows that it is indeed feasible to reach such higher targets, and highlights the key requirements needed to do so.

This analysis examines sectoral pathways, drivers for change, and cross-sectoral implications for the EU, taking the UK’s departure into account.2 This report summarises the main conclusions of this analysis and is intended to inform the debate on the increase of EU’s Nationally Determined Contribution (NDC) under the Paris Agreement.

All the initial pathways can be explored in a webtool version of the CTI 2050 Roadmap Tool (designed for the EU-28, including the UK) featuring:

• A range of scenarios that online users can explore to better understand the results;
• Links to the new scenarios developed in this report which allow the user to better understand the underlying drivers and the implications across sectors of their choice;
• An option to switch to a live version of the webtool, which stakeholders are invited to use to explore, design, and propose their own pathways. These are available at: https://stakeholder.netzero2050.eu
• Sectoral presentations are available to explain the assumptions and model logic in more detail. These can be found at: https://europeanclimate.org/net-zero-2050/

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1 See the Climact report (2018), Net zero by 2050: from whether to how. Zero emissions pathways to the Europe we want. September 2018
2 More precisely, from each pathway modelled with the CTI 2050 roadmap tool, UK emissions and activities have been subtracted, assuming the UK follows its own pathway but with similar 2030 targets (-55% or -65%) and similar policy orientation (see Annex I for more details).
DISCLAIMER

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THE ANALYTICAL TEAM (CLIMACT)

Jerome Meessen, Julien Pestiaux, Michel Cornet, Quentin Jossen, Benoit Martin, Vincent Matton, Charles Vander Linden, Pascal Vermeulen

³ For more information, please contact Linda Kalcher (Linda.Kalcher@europeanclimate.org).
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Public awareness of the risks and impacts associated with climate change has increased considerably in recent years: 93% of Europeans consider climate change a serious problem.\(^4\) Temperature records have been exceeded regularly over the last years, exposing the EU’s vulnerability to extreme weather events.

The Intergovernmental Panel on Climate Change (IPCC) special report published in 2018 on the impacts of global warming of 1.5°C above pre-industrial levels outlined the urgent need for action to maintain safe temperature thresholds.\(^5\) It indicates that countries need to achieve net-zero greenhouse gas emissions by around mid-century and, more importantly, to cut emissions significantly over the next decade. The UNEP Emissions Gap Report 2019 estimated that from 2020 the required cuts in global emissions needed in order to have a reasonable chance of meeting the relevant temperature goals are 2.7% per year for the 2°C goal and 7.6% per year on average for the 1.5°C goal. For the EU, the 1.5°C goal would result in a ~68% reduction in greenhouse gas emissions by 2030, surpassing the current emissions reduction target by at least 40%.

The growing anger about this mismatch between scientific evidence and governmental policies has led to millions of young people demanding more ambitious climate action. The call by youth has been echoed by the support of business,\(^6\) trade unions,\(^7\) ministers\(^8\) and the European Parliament\(^9\) for a 55% emissions reduction target for 2030. In response, the European Commission has enshrined pledges to reduce emissions by 50-55% by 2030 and to make Europe the first climate-neutral continent by 2050 in the heart of its Green Deal. Even during the COVID-19 crisis, this commitment has been reconfirmed and backed by the vast majority of EU countries.\(^10\)

Beyond the scientific and societal reasons for the EU to take action, there is also the international dimension. When the Paris Agreement was adopted by 195 countries in 2015, it enshrined the core objective of keeping the global average temperature rise to well below 2°C above pre-industrial levels, and pursuing efforts to keep it to 1.5°C. An “ambition cycle” of regular reviews and upgrades of pledges was included to ensure that countries’ plans align with science over time. 2020 is the political deadline by which countries are expected to pledge more ambitious climate plans to the UN, despite the postponement of the 26th UN climate conference (COP26) until next year.

Since the adoption of the Paris Agreement five years ago, enabling conditions for higher 2030 targets in the EU have improved. Among these are:

- More and more countries, companies and sub-national governments are setting net-zero emission targets for 2050 or well before;
- New and updated laws are incentivising a clear shift away from fossil fuels and carbon-intensive production or consumption;
- Technologies relying on renewable energy sources have become cheaper and more widely available (e.g. electric vehicles);
- Financial actors are applying more scrutiny with regard to fossil fuels being included in their portfolios;
- Higher societal awareness is leading to more and more citizens making sustainable choices regarding individual transport and diet.

This report intends to inform the ongoing political debate on the increase of the EU’s 2030 climate target by presenting three possible scenarios for emissions reduction by 55% and 65% by 2030. The underlying online tool\(^11\) allows for more variation and for the reader to apply his or her own choices to the mix of options available.

The three scenarios that present pathways for the 27 EU countries to reduce emissions by 55% or 65% by 2030 were developed before the COVID-19 crisis occurred. Given the unpredictability of the economic and social impact of the crisis and the unreliability of forecasts on related emissions reductions, this report does not factor them in. Initial assumptions suggest that some of the changes required to achieve a 65% emissions reduction might be more desirable in the short-term, such as:

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4 See the EC survey (2019): Citizen support for climate action.
5 See the IPCC report (2018): Global warming of 1.5°C
6 See the following article from the Corporate Leaders Group: Link
7 See the following article from the European Trade Union Confederation: Link
8 See the following article from Reuters: Link
9 See the following article from Euractiv: Link
10 See the Climate Home News publication (2020): European Green Deal must be central to a resilient recovery after Covid-19
11 See https://stakeholder.netzero2050.eu/.
• less air travel out of concern that the virus spreads more easily in planes;
• less commuting and increased cycling due to increased homeworking;
• changed production and consumption patterns or acceleration to the circular and functional economy due to the greater risk of disruption in supply chains.

However, the longevity of such changes is difficult to predict. Policies provide a stable and reliable framework for the transition. From a climate policy perspective, this period has enabled the EU to consider in a different light socio-economic questions that could be answered if the EU-27 decides to align its economic recovery with the accelerated transition to net-zero emissions by 2050, such as:

• How to ensure that investments to stimulate economic recovery are not creating further fossil fuel dependency or inertia ("lock-ins") or delaying the transition in key sectors where zero-carbon technologies are available (power, road transport)?
• How can these investments enable the profound changes required to move industry to a circular economy?
• How to avoid any dramatic rebound effects of environmentally harmful consumption?
• How to foster the role of the scientific community and facts in policy decisions?

This crisis has shown us that the resilience of the economy, i.e. its intrinsic capacity to recover from a shock, is as important as its productivity and competitiveness. Improving the resilience requires both reducing the exposure to risks (e.g. by reducing dependences or diversifying supply sources) and increasing the economy’s sustainability and capacity to answer citizens’ needs. An ecological and social transition will avoid, delay or mitigate the effects of future crises, most notably the climate crisis. A zero-carbon economy is more resilient due to a lower dependence on energy, raw material imports and the volatility of fossil fuel prices, and also because of the improvement in public health, reduced energy bills and the restoration of biodiversity.
EXECUTIVE SUMMARY

OBJECTIVE OF THIS REPORT

Public demands for policy-makers to make robust plans for tackling climate change have increased in recent years. In response, the European Commission has suggested raising the EU’s current 2030 greenhouse gases (GHG) emissions reduction target from the current level of “at least -40%” to either -50% or -55% (excluding land use, land-use change, and forestry (LULUCF) and international bunkers, compared to 1990 levels).12

This work uses the CTI 2050 Roadmap Tool, a transparent simulation model of total EU GHG emissions, to test and discuss the technical potential for meeting higher 2030 emissions reduction targets.

Various pathways leading to a 55% and 65% GHG reduction in 2030 compared to 1990 and to net-zero emissions by 2050 were tested. Three of them are described in detail in this report in order to support a more informed debate about the required level of EU action:

- The **55% Technology-focused Scenario** deploys technologies much faster than the current pace. This includes upscaling mature technical solutions and accelerating the development of those currently at lower Technology Readiness Level (TRL). This technology-focused scenario demonstrates what can be achieved without fundamentally changing today’s lifestyles, while raising deployment, infrastructure, innovation and R&D challenges. The EU-28 version of the 55% Technology-focused Scenario can be explored at the following [LINK](#).

- The **55% Shared Effort Scenario** reduces the effort on some technological developments but includes more action on lifestyle and socio-cultural changes (modes of travel, including fleets of shared vehicles, healthy diets, consumption and production patterns, etc.). On top of reducing GHG emissions, these societal changes reduce the need for capital investment and infrastructure deployment as well as the total cost of the energy system (and energy bills for EU citizens). This scenario also leads to higher co-benefits, for example regarding health, biodiversity, landscapes and ecosystems. The EU-28 version of the 55% Shared effort Scenario can be explored at the following [LINK](#).

- The **65% Scenario** involves faster action on both the societal and technology sides. Though technologies here are rapidly deployed, many of the supply technologies do not need to be deployed on the same level as in the 55% Technology-focused Scenario thanks to the significant GHG benefits of the demand-side options.13 The EU-28 version of the 65% Scenario can be explored at the following [LINK](#).

The precise level of implementation required across the main technological or lifestyle options are captured in the beginning of each sector-focused section.

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12 See the EC publication (2014): 2030 climate & energy framework. The current framework adopted by the European Council in October 2014 targets at least 40% cuts in greenhouse gas emissions (from 1990 levels), at least 32% share for renewable energy and at least 32.5% improvement in energy efficiency. The scope of this targets does not include LULUCF and international bunkers.

13 All three scenarios can be explored at the following [LINK](#).
KEY FINDINGS

This analysis finds that the EU-27 can cut its emissions by 55% or 65% by 2030 (compared to 1990, excluding land use, land-use change, and forestry (LULUCF) and international bunkers). For the 55% target, some flexibility still exists across policy options. For example, it is possible to cut GHG emissions by 55% by rapidly deploying known technologies without significant changes to most of our current ways of living (this is investigated in the 55% Technology-focused Scenario). Alternatively, further improving our lifestyles (for example through healthier diets and reducing unnecessary travel) could cut EU emissions by 55% while allowing a more moderate deployment of technologies (this is explored in the 55% Shared Effort Scenario). Reducing emissions by 65% by 2030 is feasible through rapid action on both technology deployment and lifestyle improvements. This is illustrated in Figure 1 and Figure 2, which show how emissions cuts by 2030 could be achieved with varying levels of sectoral efforts, of carbon capture and storage (CCS) contribution for industry and of power generation profiles.

FIGURE 1. ANNUAL GHG EMISSIONS OF THE EU-27, EXCL. LULUCF AND BUNKERS [MtCO2e]
All of these scenarios will require supportive policies and swift implementation by stakeholders. The benefits of a well-managed transition are likely to include a reduction in total energy costs in the mid-term, more energy security, improved health and air quality, more comfortable housing, more resilience to shocks in raw material supply chains and improvements in biodiversity protection and the restoration of landscapes and natural ecosystems.

The most important task for policy-makers is to ensure that financial flows guide the sectoral transitions, especially as part of the stimulus and recovery support in response to COVID-19 and workforce plans are designed to allow for a just transition. That said, the impact of cutting emissions by 55% or 65% on the overall economy and on overall employment is estimated to be small compared to the impact of broader trends such as digitalisation and automation, or to the financial and human costs resulting from climate damage if measures to limit greenhouse gas emissions are insufficient.  

Several encouraging developments over the last years indicate that a wide range of zero-carbon technologies are available and ready to be deployed at much higher levels than at present. Many companies are also already defining themselves through climate leadership, while increased environmental awareness and existing trends in lifestyles are already driving change on the consumption side (e.g. recent mobility and diet changes).

[See EC publication (2014): New study quantifies the effects of climate change in Europe]
CROSS-SECTORAL FINDINGS

To achieve a cost-effective transition to net-zero emissions by 2050, no sector can be left aside, and policy design needs to factor in the tight interconnections between sectors. The link between climate and wider sustainability also highlights important win-wins, requiring constant attention to the consistency between policies.

Some key examples of interdependence between sectors include:

- Power sector decarbonisation, which can speed up the reduction of emissions through electrification in other sectors. Delaying energy decarbonisation forces other sectors to reduce emissions by other means, such as changes in lifestyle;
- The required shift to a more circular economy, coupled with a stronger focus on services rather than goods, which reduces material requirements and consequently manufacturing emissions;
- Agricultural and forestry practices which, depending on their evolution, can either increase emissions or increase carbon dioxide removal by sinks, but also drive the domestic potential of sustainable biomass from their residues and by-products;
- The connection between the scale of technological deployment and required adaptations to our ways of living as illustrated by the contrasted options activated in the studied scenarios.

While a more technology-focused scenario reduces the reliance on large-scale lifestyle changes in the short term, the scale of additional infrastructure needed might not find social acceptance, especially in the case of carbon capture and storage facilities.

Beyond the benefits for each sector, there are several advantages stemming from a higher GHG target by 2030:

- First, it reduces the effort required between 2030 and 2050: sticking to -40% in 2030 leads to almost doubling yearly reduction compared to 2020 from -2.2% to -3.9%, while a more ambitious target of -55% brings this rate down to -2.9% after 2030, and -65% in 2030 brings it to -2.3%.\(^\text{15}\)
- Beyond this, increasing ambition allows Europe to seize a leadership position on low-carbon economy technologies and policies, and it can help reduce the total cost of the transition by pushing innovation early and avoiding carbon intensive lock-ins.

\(^\text{15}\) In absolute numbers, if emissions are reduced by -55% in 2030, then emissions still need to reduce by -93MtCO₂/year compared to the 2020 figure, and if they are reduced by -65% this comes down to -77MtCO₂/year. This compares to -135MtCO₂/year with the European Commission’s Long-Term Strategy.
**TRANSPORT**

**Historical trends in both road and air travel are not aligned with reaching -55%, let alone -65%, by 2030. Policy-makers must urgently support a faster uptake of a variety of cleaner alternatives in road transport on climate, competitiveness and health grounds. A new framework is also required to catalyse investment and innovation in sustainable aviation fuels and new aircraft designs, while limiting the increase in demand.**

**TABLE 1. TRANSPORT HIGHLIGHTS (SEE SECTOR DETAILS FOR ADDITIONAL INDICATORS)**

<table>
<thead>
<tr>
<th>Category</th>
<th>Action</th>
<th>55% Technology-focused</th>
<th>55% Shared Effort</th>
<th>65%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Passengers</strong></td>
<td>Reduce transport compared to 2015</td>
<td>-5%</td>
<td>0%</td>
<td>-10%</td>
</tr>
<tr>
<td><strong>Passengers</strong></td>
<td>Share of zero-emissions cars in 2030 new sales</td>
<td>88%</td>
<td>60%</td>
<td>93%</td>
</tr>
<tr>
<td><strong>Freight</strong></td>
<td>Modal share of trucks (2015=50%)</td>
<td>45%</td>
<td>45%</td>
<td>42%</td>
</tr>
</tbody>
</table>

Transport is a major and growing source of GHG emissions in Europe. Options exist to accelerate the decarbonisation of road transport, and can positively impact quality of life, for example by ensuring less pollution and noise in cities. Electric vehicles are one of the key technologies required and have reached similar lifetime cost levels to their conventional alternatives, but they need to reach a much faster uptake with ~60% to ~90% of new sales by 2030 or shortly after for all three scenarios examined here, particularly as cars must increasingly be built to last longer in light of a more circular economy. This technological shift will require decarbonising electricity, while ramping up its production and ensuring smart integration of the transport and power sectors.

Demand-side measures such as increased modal shift to public transport or bicycles, as well as increased car sharing and shifting to Mobility as a Service (MaaS) would help in reducing the reliance on large fleets of cars requiring a lot of raw materials. The 55% Shared Effort Scenario and the 65% Scenario rely on these demand-side measures along with the technological ones, encouraging a new vision of mobility with a larger place for alternative modes and improved fleet management for passenger cars.

Historical trends in aviation (before the COVID-19 crisis) are a growing problem within the transport sector. In a technology-focused scenario, policies therefore need to support intensified innovation on the technical side, both in fuels and aircraft. Even if these contribute to a limited degree to emissions reductions by 2030, they are critical to reducing emissions in the transport sector in the medium term. Regulatory incentives or adequate pricing mechanisms on fuel and carbon can restrain the current increasing trends in air transport. The 55% Shared Effort Scenario assumes that on average, the demand for air travel is roughly stabilised at 2015 levels across the EU.

The recent COVID-19 crisis might lead to lasting changes in our transport patterns. Health concerns about the virus spreading more easily in closed environments could disincentivise people from flying and temporarily turn around the growth trend in air travel. However, only policies can shape predictable transitions for the aviation industry to avoid its growing impact on climate change.
BUILDINGS

Renovation rates will need to at least double or triple, and these renovations will need to be carried out much more thoroughly. Deep renovation does not lead to an immediate return on investment, but it does bring many co-benefits, from increasing the quality of housing and therefore wellbeing, lowering energy costs and thereby reducing energy poverty and boosting employment in the construction sector. The European Commission can ensure that its Renovation Wave incentivises and provides financial mechanisms to achieve these deep renovation levels.

TABLE 2. BUILDINGS HIGHLIGHTS
(SEE SECTOR DETAILS FOR ADDITIONAL INDICATORS)

<table>
<thead>
<tr>
<th>Category</th>
<th>Action</th>
<th>55% Technology-focused</th>
<th>55% Shared Effort</th>
<th>65%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>Annual renovation rates</td>
<td>2.3 %/year</td>
<td>3.4 %/year</td>
<td>3.5 %/year</td>
</tr>
<tr>
<td></td>
<td>Average energy savings after each renovation</td>
<td>80%</td>
<td>81%</td>
<td>82%</td>
</tr>
<tr>
<td>Non-residential</td>
<td>Renovation rate</td>
<td>2.5 %/year</td>
<td>2.5 %/year</td>
<td>3.5 %/year</td>
</tr>
</tbody>
</table>

Policies need to ensure that building renovation is started in earnest, together with the decarbonisation of heating supply. Renovation rates for buildings will need to ramp up over the next decade to double or triple today’s level by 2030, while renovation depth must reach an average “factor 4” (~75% energy consumption after renovation on average). This will require innovation to digitalise and industrialise the refurbishment of houses on a large scale and at reasonable cost. Positive signs include the ambitious renovation policies already in place in several Member States. At the same time, heat production needs to be decarbonised leveraging all of the alternatives based on local circumstances, from heat pumps and solar thermal to district heating.
INDUSTRY

All scenarios clearly demonstrate that EU industry must seize the opportunities of the circular and functional economy (where assets are rented, leased or shared, substituting ownership), to achieve net-zero emissions by 2050 at the latest. The three scenarios offer different ways to align the industry with the right trajectory of GHG reduction by 2030.

TABLE 3. INDUSTRY HIGHLIGHTS (SEE SECTOR DETAILS FOR ADDITIONAL INDICATORS)

<table>
<thead>
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<th>2030 TARGETS IN THE 3 SCENARIOS</th>
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<tr>
<td><strong>Action</strong></td>
</tr>
<tr>
<td>Share of recycled materials in new products</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Annual CCS</td>
</tr>
</tbody>
</table>

The circular economy and the functional economy have many co-benefits, including increasing the intrinsic value of EU products, maximising the use and improving EU resilience to raw material supply chains. A comprehensive approach across industries and matching workforce plan are required to ensure a well-managed transition, especially as all three scenarios indicate that there will be significant changes in employment.16

In the 55% Technology-focused Scenario, heavy industry is put on a trajectory that relies on the early deployment of relevant low-carbon technologies and infrastructure, including carbon capture and storage, but without harnessing the potential of circularity. In particular, in this scenario carbon capture and storage deployment would accelerate to reach 24 MtCO2e captured and stored by 2030 (see Figure 1), which is in line with what the Netherlands has committed to achieving (with 7 MtCO2e to be captured and stored every year by 2030).17

In the 55% Shared Effort and the 65% scenarios, the circular economy and functional economy are more developed, complemented by necessary changes to ownership models. As a result, the required manufacturing of new products (e.g. vehicles, building materials) and the related investment costs in the sector are reduced. The 55% Shared Effort Scenario therefore requires less carbon capture and storage by 2030 (see Figure 1 and Table 8). In the 65% Scenario, the transition in industry towards circularity, functional economy and process efficiency is accelerated and would require rapid adjustments of employment patterns.

To achieve emissions reductions in line with the scenarios, investment, research and development need to increase by 2030. The transition is encouraged by hundreds of companies already setting science-based targets to reduce their direct and indirect GHG emissions, thereby aligning their strategy with the Paris Agreement and the EU Green Deal.

16 While this study did not explore the social impacts of the transition, many of the sectoral changes we explored are likely impacting employment, especially at the regional level. The EU and Member states need to pay special attention to dislocations of labour across all sectors that will be affected.
17 See the National Climate Agreement of the Netherlands.
Solar and wind deployment rates will need to at least double or triple and coal will largely be phased out by 2030. Leaving the coal phase-out to later than 2030 makes it impossible to cut emissions at the pace required to meet the temperature goals of the Paris Agreement. Gas demand is also at least cut in half by 2030 (compared to the 2019 level) in all scenarios, so it will be important to minimise any new investment in gas infrastructure, which would become a stranded asset in the future.

### TABLE 4. POWER HIGHLIGHTS
(SEE SECTOR DETAILS FOR ADDITIONAL INDICATORS)

<table>
<thead>
<tr>
<th>Action</th>
<th>55% Technology-focused</th>
<th>55% Shared Effort</th>
<th>65%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal-based power generation (2019 = 470 TWh)</td>
<td>50 TWh</td>
<td>41 TWh</td>
<td>25 TWh</td>
</tr>
<tr>
<td>(And no more coal by 2040)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual increase of production by Wind and Solar between 2020 and 2030 (annual addition between 2010 and 2018 = 40 TWh)</td>
<td>135 TWh/year</td>
<td>81 TWh/year</td>
<td>89 TWh/year</td>
</tr>
</tbody>
</table>

Power generation is a major source of GHG emissions in Europe, even though it has decreased in recent years with coal being priced out of the market and the deployment of renewable energy sources (RES). The further decarbonisation of power requires further accelerating the phase-out of coal down to 50 TWh (in the 55% Technology-focused Scenario) and 25 TWh (for the 65% Scenario) and moving directly to renewable energy, without adding new capacity in gas. This is a continuation of recent trends, as between 2012 and 2019 we already saw a 47% reduction in coal power generation. 74 GW of coal power capacity has been closed since 2010 and 73 GW or 48% of remaining capacity is located in countries which have announced they will phase out coal by 2030 or earlier.18 Gas usage decreases over time, even in the 55% Technology-focused Scenario. This scenario has the largest demand for power and shows a share of renewable energy production of 72% in 2030, of which 60% is only wind and solar.

Demand-side measures help reduce the pressure on the technological shift by enabling a lower increase in electricity demand. This is highlighted in the 55% Shared Effort and the 65% scenarios which rely heavily on both demand-side and supply-side measures in other sectors, reducing the challenge in the power sector.

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18 Europe Beyond Coal: Overview: National coal phase-out announcements in Europe Status April 2020
**AGRICULTURE, LAND USE AND BIOENERGY**

The EU can no longer ignore the role of agriculture and land use in relation to reducing GHG emissions. Policy-makers should therefore urgently explore pathways that tackle this major driver of emissions while taking into account both the changes in farming and the co-benefits for biodiversity. The scenarios analysed outline the trade-offs between changing demand for agricultural products and increasing agricultural efficiency.

**TABLE 5. AGRICULTURE HIGHLIGHTS**
*(SEE SECTOR DETAILS FOR ADDITIONAL INDICATORS)*

<table>
<thead>
<tr>
<th>Action</th>
<th>55% Technology-focused</th>
<th>55% Shared Effort</th>
<th>65%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce meat consumption per person (vs 2015)</td>
<td>-11%</td>
<td>-28%</td>
<td>-32%</td>
</tr>
<tr>
<td>Reduce land requirement per unit produced thanks to land multi-use (land sharing and crop rotation)</td>
<td>-17%</td>
<td>-17%</td>
<td>-17%</td>
</tr>
<tr>
<td>Demand for liquid biofuels vs 2015</td>
<td>-17%</td>
<td>-16%</td>
<td>-51%</td>
</tr>
</tbody>
</table>

By 2030, agricultural emissions are reduced by at least 25% compared to 2015 in the three scenarios presented (at least -39% compared to 1990). Irrespective of the scenario, no-regret actions include a maximum reduction of food waste (both at the farm and after farm), mainstreaming land multi-use (sharing land for different compatible, sustainable uses or allowing more frequent crop rotation) and increasing healthy diets (including reducing the level of meat consumption and the share of meat from ruminant animals).

Diets are key drivers for improving health. In that context, the 65% Scenario is the most closely aligned with World Health Organisation’s (WHO) health and nutrition recommendations.

If diets are not improved, technical measures will be required to make agriculture more productive with the consequent risk of further harming biodiversity and not being aligned with the chemical fertiliser and pesticide targets of the European Commission’s “From Farm to Fork Strategy.”

As an illustration, the 55% Technology-focused Scenario requires a larger increase in agricultural yields (+1.14%/year) than the increase observed in recent years in Europe (e.g. +0.7%/year for wheat between 2000 and 2018). The 55% Shared Effort Scenario requires a much lower yield increase thanks to the -28% reduction in meat consumption (compared to 2015).

Land use must be part of the climate policy debate as it provides significant potential for carbon capture in forests, biomass and soils, which is critical to reaching net-zero emissions by 2050. On that basis land use will significantly evolve in parallel to any 55% or 65% emissions reduction scenario and this will in turn drive the availability of low-value residues and by-products from agriculture and forestry which can potentially be converted into sustainable bioenergy for the other sectors.

Bioenergy demand in the three scenarios clearly breaks with the increasing historical trend, staying comparable to the demand in 2015, with the demand for liquid biofuels decreasing by at least 10% in 2030 compared to today. As a consequence, none of the scenarios require increasing bioenergy imports. In all three scenarios the biomass feedstock mobilised differs from today’s feedstock by focusing on more sustainable sources composed of relatively more residues from agriculture and waste. In particular, the land specifically dedicated to bioenergy crops is phased out in all scenarios by 2030 or shortly thereafter.

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19 See the EC “From Farm to Fork Strategy” report (2020).
20 See OECD data.
THE EU CAN REDUCE ITS EMISSIONS BY 55% OR 65% BY 2030

INTRODUCTION TO THE APPROACH

The CTI 2050 Roadmap Tool\textsuperscript{21} was used to test options to increase European ambition to reach 55% and 65% reductions in GHG emissions by 2030, in line with the goals of the Paris Agreement. Three scenarios are described further in this report to describe the concrete actions required to reach these higher targets.\textsuperscript{22}

- A technology-focused scenario which achieves a 55% reduction in GHG emissions by 2030 (the 55% Technology-focused Scenario), and net zero in 2050, by deploying technologies much faster than the historical pace:
- A more alternative scenario achieving a 55% reduction in GHG emissions by 2030 (the 55% Shared Effort Scenario) with action on both technology deployment and lifestyle changes reducing the demand for emitting activities:
- A scenario achieving a reduction of 65% in GHG emissions by 2030 (the 65% Scenario), moving beyond both 55% scenarios with more activating levers on both the demand and the technology sides:

All three scenarios require significantly increasing the pace of action across all sectors, leveraging a wide range of levers such as faster renovation rates coupled with much deeper renovation, increasing the uptake of electric vehicles, ensuring a near coal phase-out by 2030 and its replacement by renewable energy sources as well as improving processes in the industry and deploying carbon capture and storage and rethinking eating habits.

In the case of the 55% Technology-focused Scenario, the focus is on technology levers, maximising the deployment of existing technologies. With the right policies and incentives, a rapid and steep reduction can be achieved in all sectors to reach the 55% target. Special attention by policy-makers is required to allow for a managed transition of the workforce through education, training and proper planning. The 55% Shared Effort Scenario mitigates the risk of technological deployments by accelerating the transformation of our lifestyles and in the way our society is organised, reducing the need for power production and manufacturing in the future.

Reaching a 65% reduction target is doable by exploiting both rapid technology deployment and changes in our lifestyles and in the way our society is organised. Adding demand-side levers such as more limited growth in transport demand and shifting to softer transport modes like bicycles and public transport, reducing our meat consumption, and limiting our use of carbon-intensive products allows the EU to reduce emissions further to -65%. Societal levers are powerful in the 2030 timeframe because they could ramp up relatively quickly if citizens are willing to make these changes. They are partly based on individual choices regarding transport, diet and product consumption, but also require our societies to be organised differently, and a series of clear choices in terms of infrastructure. Emerging trends suggest this is happening in some countries or societal groups but cannot be guaranteed across all countries at same scale. This report clarifies where the potential for these levers will make a difference and in which sectors. Specific policies can be detailed based on the findings, but this is beyond the scope of this report.

\textsuperscript{21} See the section “Background to this work” for further information on the model and its assumptions.
\textsuperscript{22} All three scenarios can be explored at the following LINK.
FINDINGS ACROSS SECTORS AND SCENARIOS

POLICY COHERENCE ACROSS SECTORS IS ESSENTIAL BECAUSE OF THEIR TIGHT INTERDEPENDENCE

Higher ambition is only feasible with engagement from all sectors. Figure 3 illustrates how all sectors reach at least a 30% emissions reduction below 2015 in all scenarios.

It is also important to understand how interdependent the various sectors are, and the impact this has on the necessary policies over the next decade.

Power has the highest reduction potential as it is one of the cornerstones of the decarbonisation of demand-side sectors, particularly in transport, and it has an emissions reduction potential of over 90% by 2030. Policy-makers can incentivise a fast coal phase-out to ensure emissions are reduced while the other sectors are electrified. Early electrification in the transport sector can reduce emissions when additional renewable energy supply matches increased power demand.

To maximise the potential of the circular and functional economy across all sectors, policy-makers need to design a comprehensive set of policies to apply before 2030. A series of options exist to use products and materials much more efficiently, extending their lifetimes and ensuring their extended use, sharing, reuse and refurbishments. The associated challenges in product design, production and maintenance, as well as changes in the business model will be significant for many types of assets, from cars, houses, appliances, waste streams and even energy. These transformations can have major trickle-down effect on the economy, making a much larger emissions reduction possible. However, these transformations will also have profound impacts on the way we live and consume as well as on employment, which will need to be managed.
In policy design for construction and buildings, the long-term perspective needs to be taken into account. Even if the construction sector increases its demand for materials, it makes sense to increase renovation rates massively before 2030 to ensure buildings are fully decarbonised by 2050. There can be an economic trade-off, however, between the depth of renovation as well as the amount of demolition or reconstruction, and the decarbonisation of heating. Higher building renovations require more materials, and this trend can lead to higher emissions in the industry sectors, particularly as steel and cement are very carbon-intensive. Companies producing materials must be encouraged to start using more bio-based materials (e.g. wood and hemp) and improve their production processes.

Sustainable bioenergy can play a limited role in reducing emissions when other decarbonisation technologies are not yet available. This however is only credible if combustion emissions are fully offset by carbon capture during the biomass growing phase, which is the case for the sustainable feedstock considered in this study, mainly coming from residues and by-products from agriculture and the wood industry. However, to avoid exploiting or importing unsustainable biomass beyond domestic potential, other zero-carbon solutions must be rapidly deployed: policies that ensure R&D in transport, industry and buildings will allow bioenergy requirements to remain sustainable.

A STRONGLY TECHNOLOGY-ORIENTED SCENARIO LIMITING THE SOCIETAL CHANGES RAISES OTHER RISKS WHICH DESERVE CAREFUL ATTENTION

This report focuses on analysing scenarios in terms of GHG emissions, energy consumption, land use and other emissions drivers.

In this framework, the 55% Technology-focused Scenario reaches its 2030 target by assuming limited changes in lifestyle (e.g. travel demand, diet, consumption of products or strong circular economy principles) and by limiting the decrease in industrial production thanks to a fast deployment of technical solutions.

However, other sustainability issues deserve careful attention since large-scale technological development may potentially raise risks such as:

- Excessive consumption of raw material resources, demanding large resource extraction;
- Biodiversity degradation from the extraction of these minerals as well as the increased use of agricultural entrants;
- The social acceptance of large-scale infrastructures, and their impact on land use and biodiversity;
- Potential leakages of pipelines and storage sites when relying on carbon capture and storage;
- Inertia (lock-in) in infrastructure and consumption patterns which would not be sustainable in the longer term.
A JUST AND WELL-MANAGED TRANSITION IS KEY TO REACHING 65%

The analysis shows that a 65% reduction by 2030 only leaves marginal room for manoeuvre between sectors or levers. Achieving cuts at this scale logically requires increasing the ambition for most levers, particularly on the demand side, and also shortening the time to reach their full implementation.

Societal and technological changes need to be deployed very quickly in parallel while a just transition across all sectors is vital. Typically, the demand for transport must be reduced while massively shifting to electric vehicles and adjusting job patterns. This raises challenges for the car manufacturing industry as the demand for new vehicles drops significantly while new investments are required in new production facilities.

Some technologies which are not yet commercialised at large scale and/or competitive economically must see their first deployments by 2030, in particular carbon capture and utilisation (CCU) and start to shift to green hydrogen (based on renewable energy) in the industry.

COST REDUCTION AND OTHER CO-BENEFITS OF RAISING THE 2030 AMBITION

Beyond the benefits described for each sector, there are other clear advantages of an ambitious 2030 target. To start with, the early activation of demand-side (e.g. as in the 65% Scenario) and energy efficiency measures reduces the cost of the transition (see Figure 4).

It is worth noting that the total cost differences are stronger after 2030 once the demand-side measures implemented before 2030 deliver their full benefits. The reduction in cost comes from lower annual fuel costs, but also from requiring less investment based on better asset utilisation. This is typically the case in transport where the trend to use vehicles as a fleet rather than owning them privately can be reinforced. A more technology-oriented scenario, such as the 55% Technology-focused Scenario, requires more investment until 2030 (+51% investment in 2030 compared to 2016, up to €1,076bn in this model) which then permits avoiding fuel cost increases (see Figure 4).

![Figure 4. Total Energy System Costs in 2016 and in 2030 (BN€)](chart.png)
Secondly, delaying the “no regrets” actions (see sector details) after 2030 also creates lock-ins, stranded assets, and reduces the set of emissions reduction options available. Some of the required investments have intrinsically long lead times and/or require R&D programmes, so delay will mean some reduction options (e.g. electricity infrastructures, renovation of existing buildings, GHG removal technologies, afforestation and land-use policies) are lost in the required time frame – creating the risk that reaching net-zero by 2050 will become more difficult or even impossible.

Finally, the pace of emissions reduction required after 2030 – after reaping the lower hanging fruits – would be more strenuous if ambitious action is postponed until after 2030 compared to the 55% scenarios (max -93 MtCO2e per year). Delayed climate action would therefore make the transition harder to achieve in the medium term.
TRANSPORT

• Transport is a major and growing source of GHG emissions in Europe and historical trends in both road and air travel are not aligned with reaching -55%, let alone -65%, by 2030.

• There is untapped potential to accelerate the transition in transport and to positively impact quality of life, policy-makers must urgently support a faster uptake of a variety of cleaner alternatives in road transport on climate, competitiveness and health grounds.

• Alternative technologies exist but need a much faster uptake. This technological shift will require decarbonising power to meet higher electricity demand.

• Aviation emissions need an urgent coordinated policy response, regulatory incentives and adequate pricing mechanisms to limit the increase in demand, while a new framework is also required to catalyse investment and innovation in sustainable aviation fuels and new aircraft designs.
TRANSPORT IS A MAJOR AND GROWING SOURCE OF GHG EMISSIONS IN EUROPE

Slow progress and lack of action in the transport sector threaten the EU’s climate ambitions and the competitiveness of Europe’s automotive industry. Apart from the years between 2008 and 2012, where the economic crisis which affected the European economy led to a reduced transport demand, the emissions from the sector have been steadily increasing over the last decades. In fact, it is the only sector in which GHG emissions have grown since 1990. In 2017, transport (including road and rail, aviation and shipping) was responsible for 27% of domestic GHG emissions in Europe, second only to energy production. This is caused by a steadily increasing demand for freight and passenger transport.

UNTAPPED POTENTIAL TO ACCELERATE THE TRANSITION IN TRANSPORT AND TO POSITIVELY IMPACT QUALITY OF LIFE

A variety of measures can be taken to support a significant decarbonisation of the various transport modes by 2030. Some can be grouped as technological solutions (supply-side measures) such as shifting to electric vehicles, plug-in hybrids that drive electric or fuel-cell technology, and shifting to biofuels or synthetic fuels for aviation and shipping. Others require improvements in the way mobility is currently organised and in individual transport choices (demand-side measures), such as reducing the transport demand, enabling the shift to non-emitting modes of transport (e.g. bicycles, walking), increasing the occupancy of vehicles and their utilisation through fleet management and Mobility as a Service (e.g. car-sharing).

Implementing these options jointly can lead to emissions reductions and positively affect quality of life, particularly in many cities where noise and air quality have been deteriorating, and where traffic jams have increased. Focusing only on one group of solutions runs the risk of either falling too short in terms of ambition or leading to a large increase in the number of vehicles on the road and in raw material demand to produce these vehicles, traffic jams and pollution.

Table 6 highlights the concrete levels that must be reached across the key levers for the three scenarios.

<table>
<thead>
<tr>
<th>Subsector</th>
<th>Lever</th>
<th>55% Technology-focused Scenario</th>
<th>55% Shared Effort Scenario</th>
<th>65% Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger</td>
<td>Transport demand</td>
<td>Average transport demand per person across Europe increases by 5% by 2030.</td>
<td>The average transport demand per EU citizen is stabilised.</td>
<td>The average transport demand per EU citizen decreases by 10%.</td>
</tr>
<tr>
<td></td>
<td>Modal shift</td>
<td>The use of cars in passenger transport decreases from 80% of passenger kilometres (km) in 2015 to 73% in 2030.</td>
<td>Car use goes further down to 70% in 2030, shifting to other modes.</td>
<td>Car use goes further down to 66% in 2030.</td>
</tr>
<tr>
<td></td>
<td>Utilisation rate and occupancy</td>
<td>The passenger distance per car and occupancy remain at their 2015 level in 2030, passenger.km/vehicle.km</td>
<td>The passenger distance per car increases ~50% to 18,000 km/year in 2030. The occupancy increases to 2.1 passenger.km/vehicle.km in 2030</td>
<td>The increases are similar to the 55% Shared Effort Scenario</td>
</tr>
<tr>
<td></td>
<td>Technology share</td>
<td>In 2030, 88% of new cars are Zero-emissions vehicles (ZEV) (85% of which are battery electric vehicles, the rest Fuel-Cell Electric Vehicles (FCEVs)), and the rest are low-emissions vehicles (LEVs) such as plug-in hybrids</td>
<td>In 2030, 60% of new cars are ZEV (95% of which are battery electric vehicles), and 50% of the rest of sales are low-emissions vehicles.</td>
<td>In 2030, 93% of new cars are ZEV, 91% of which are battery electric vehicles and the rest of sales are low-emissions vehicles.</td>
</tr>
</tbody>
</table>

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23 See the EEA publication (2019): Total greenhouse gas emission trends and projections in Europe. Energy production includes emissions from public electricity and heat production, petroleum refining and manufacture of solid fuel and other energy industries as well as ‘fugitives’.
The increasing trend in freight transport is partly counter-balanced with the ambition on the circular economy: both effects lead to freight volumes increasing by ~20% up to 2030. The increase in volume by 2030 is limited to ~7%, which connects to the strong ambition on the circular economy, reducing material demand and the related freight transport.

Similarly to the 55% Shared Effort Scenario, the increase in volume by 2030 is limited to ~5%.

<table>
<thead>
<tr>
<th>Freight demand</th>
<th>The truck use decreases from 50% in 2015 to 42% in 2030.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modal shift</td>
<td>Same as in the 55% Technology-focused Scenario.</td>
</tr>
<tr>
<td>Technology share</td>
<td>91% of new trucks are ZEV by 2030.</td>
</tr>
<tr>
<td></td>
<td>34% of new trucks are ZEV by 2030.</td>
</tr>
<tr>
<td></td>
<td>40% of new trucks are ZEV by 2030.</td>
</tr>
</tbody>
</table>

The 55% Technology-focused Scenario focuses on accelerating technological solutions assuming demand-side measures follow their historical trends.

To reach adequate emissions reductions in line with a ~55% target, the following policies can be considered: fiscal incentives and/or tax schemes that encourage the purchase of zero-emission vehicles; stricter CO2 standards, energy efficiency labels or fuel economy standards for new vehicles; zero-emission vehicle purchase subsidies and other financial incentives; bans on the sale of vehicles with internal combustion engines (ICEs) as already adopted in many EU countries and improving electric vehicle charging infrastructure.

The impact of complementary demand-side measures is illustrated with the 55% Shared Effort Scenario. Mobility can be improved and reorganised in complementary ways. Citizens and businesses are already changing their transport modes, and technology is making it easier for people to travel less (working from home or closer to home with satellite offices, video-conferencing, etc.). While only essential commuting and homeworking were the norm during COVID-19 confinement, some might consider largely maintaining this behaviour. This scenario assumes that when travel occurs, transport is organised more collectively, either with public transport, softer alternatives like bicycles or with managed and shared car fleets. This modal shift can be a game changer, increasing the utilisation of the vehicles and making the transition cheaper as well as more manageable on the technical front (e.g. with optimised charging and fleet management). These changes allow a slower uptake of technological solutions, with a lower share of electric vehicles in total sales by 2030 around ~60%, and a much lower absolute number of electric vehicles sales required.

Achieving a 65% reduction is possible when maximising both measures: a large deployment of lower emissions vehicles must be matched by a substantial uptake on a series of demand-side measures. As illustrated in Figure 5, in a 65% scenario the individual transport demand would be curbed back to levels slightly below what we see today, with softer modes (buses, trains and two-wheelers) taking a larger share of this demand.

If car sharing becomes more common (with the average number of people travelling per car increasing from 1.6 to 2.1 (+30%), and the utilisation of the cars by 50%), the cars will be used more instead of being parked or idle ~95% of the time. This increase in the utilisation of the car fleet would significantly reduce the total number of cars on the roads (by ~53% in the 65% Scenario). Yet, car sales would not drop at the same rate as the lifetime of a car would be shorter with more kilometres driven per year due to higher usage. The added value of the car industry in this new transport paradigm is much more focused on services and maintenance than the production of goods. It also requires determined intervention by governments to manage the consequences of much lower employment in the car manufacturing sector, thereby ensuring that workers are re-trained in emerging jobs related to batteries and charging infrastructure, and affected regions are supported in the transition.24

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24 See e.g. the Camecon report: Fuelling Europe’s Future: How auto innovation leads to EU jobs.
FIGURE 5. EU PASSENGER TRANSPORT DEMAND BY MODE (BN.KMS/YEAR)

2010
5.144
469
413

2015
5.341
467
411

2020
5.382
499
441

2025
5.589
608
712

2030
5.379
748
715

5.135
758
617

Technology-focused
55%

Shared effort
55%

65%

FIGURE 6. EU TOTAL CAR FLEET IN THE THREE SCENARIOS (MILLIONS OF VEHICLES)

2010
216

2015
220

2020
221

2025
213

2030
124

103

Technology-focused
55%

Shared effort
55%

65%
Increasing the EU’s 2030 Emissions Reduction Target

Alternative technologies exist but need a much faster uptake.

Zero-emission technologies are available and ready to be deployed, and while electric vehicles are still mostly more expensive upfront, their lower fuel and operating costs mean that the Total Cost of Ownership (TCO) is becoming very similar to that of conventional vehicles.

*Figure 7. Evolution of the Car Fleet by Type of Drive (Millions of Cars)*

The technical shift of vehicle fleets to electric vehicles has slowly begun in recent years, but the pace must be increased to reach the required scale of uptake. Figure 6 shows how electric vehicles represent ~30% of the passenger fleet by 2030 in the 55% Technology-focused Scenario, requiring sales of new vehicles to ramp up over the next 10 years to making up close to 90% of electric cars by then. Buses must follow a similar trend. And freight is also being largely electrified in the 55% Technology-focused Scenario.

To do so, accompanying policies are required in the next few years. Norway is the strongest example of how policies can drive up the share of electric vehicle sales, increasing from 1–2% in 2011 to reach 42% for the full year 2019, effectively reaching a stage where critical mass of adoption is achieved. This is unique worldwide and provides a real-world picture of future electric vehicle sales proportions developed markets could experience over the next five to 10 years with technologies now much more mature than they were 10 years ago. Norway is applying a portfolio of policies which goes beyond pure financial incentives, with drivers of zero-emission cars enjoying benefits such as exemption from road tax and from 25% VAT on sales, reduced road and ferry tolls and parking costs, and access to bus lanes. These policies can be phased out as the cost of electric vehicles reduces sufficiently and the infrastructure is sufficiently deployed to make electric vehicles more attractive than conventional vehicles. They can then be replaced or complemented with bans on sales of new conventional internal combustion cars, which several countries have announced, notably Ireland, the Netherlands and Slovenia (2030), and including some with a large car industry such as France and the UK (2040).
Various policies that lead to changes in transport are also found in Central Eastern European countries, with for example an attractive car scrappage scheme in Romania where 48 thousand old, polluting cars were substituted by 47 thousand new low-emission cars in 2018. Hungary is also supporting electric vehicles with a range of policies covering the development of electric charging infrastructure as well as the introduction of the green number plate for electric vehicles and hybrids giving them access to free charging and parking. And Poland, which currently has the biggest electric bus fleet in the region is likely to reach or surpass the EU average in the upcoming years at their current rate of development. 29

These transformations are a great opportunity for European manufacturers to regain initiative by placing themselves at the forefront of innovation towards the technologies that will be needed to remain competitive globally. The largest players are starting to change their fleets, with the example of the Volkswagen group announcing a large shift to electric vehicle production in the next decade, investing €60bn in electric mobility, hybrids, and more, with the long-term plan to launch 75 electric new models and 60 hybrids by the end of 2029, and to sell 26 million electric vehicles by 2029, along with six million hybrids. 30 This is a steppingstone towards the 69 million vehicles required in 2030 in the 55% Technology-focused Scenario. Economies of scale and competition between manufacturers should continue to bring prices down, reinforcing these trends.

This transition will also require large investments in infrastructure, from charging stations to electricity and hydrogen production facilities, as well as distribution grids. The modelling for this report indicates an increase in yearly capital expenditures in the transport sector from €620 to about €820 billion euros between 2020 and 2030, of which ~€70 billion specifically related to charging infrastructure and e-highways.

THIS TECHNOLOGICAL SHIFT WILL REQUIRE DECARBONISING POWER TO MEET HIGHER ELECTRICITY DEMAND

Decarbonising transport by shifting the fleet to zero-emission vehicles and alternative fuels is only part of the picture, as these fuels also need to be decarbonised at the same time. Power demand for transport in the 55% Technology-focused Scenario increases five-fold from 2020 to 2030 (already representing 17% of total power demand in 2030), and this trend will be reinforced with the introduction of synthetic fuels later on to decarbonise the more difficult uses and modes such as aviation, shipping, and parts of freight transport. This requires a strong uptake of renewables for electricity production, with on average about 135 TWh of additional wind and power production every year in the next 10 years in the 55% Technology-focused Scenario. This means tripling the 40 TWh installed yearly on average over the past 10 years (or doubling the 64 TWh deployed in 2019) 31, reaching a yearly production of about 2050 TWh of wind and solar in 2030.

The 55% Shared Effort and 65% scenarios take advantage of demand-side measures to reduce the reliance on technological uptake only:

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30 See the Financial Times publication: Volkswagen increases investment in electric vehicles

31 See the Agora Energiewende publication (2020): The European Power Sector in 2019: Up-to-Date Analysis on the Electricity Transition
• Lower individual transport demand and higher modal shift reduce the increase in the share of electric vehicle in total sales (from about 90% of sales in 2030 in the 55% Technology-focused Scenario to 50% in the 55% Shared Effort Scenario).

• In parallel, power demand for transport, rather than being multiplied five-fold (Figure 8), would only double by 2030 if demand-side levers are added to the supply-side levers used in the 55% Technology-focused Scenario.

• Increasing the utilisation of the car fleet (e.g. by shifting to Mobility as a Service) improves the use of these valuable assets which currently sit idle 95% of the time, and reduces the car fleet: while the fleet size is stable in the 55% Technology-focused Scenario, demand-side measures allow for the reduction of the fleet by up to ~50% by 2030 in the 55% Shared Effort and 65% scenarios, and at the same time increasing the asset rotation to cleaner cars.

AVIATION EMISSIONS NEED AN URGENT COORDINATED POLICY RESPONSE, REGULATORY INCENTIVES AND ADEQUATE PRICING MECHANISMS

While passenger cars strongly reduce their energy demand in the 55% Technology-focused Scenario, other types of energy use gain importance over time, particularly in the aviation sector. Both domestic and international become major components, especially after 2030 (see Figure 9 and Figure 10). The aviation and shipping sectors are the main reason for transport to still rely on fossil fuels by 2050, even in the 55% Technology-focused Scenario.
Aviation and shipping will be harder to decarbonise than road transport. While a variety of options already exists for decarbonising road and rail transport, aviation and shipping still face significant challenges in reducing their GHG emissions. Commercial aviation, for example, has been heavily dependent on the use of liquid fuels for their jet engines and, therefore, technologies such as bio-jet fuel are an important alternative. This raises concerns related to the sustainability of bioenergy supplies and the economic and technical potential of synthetic hydrocarbons. Given the required certification processes, bio-jet fuel cannot be available before 2032 under the current regulatory framework. This means that while the focus by 2030 must be strong on cars, leaving another highly polluting mode such as air transport with no constraint will make the transition after 2030 all the harder, typically requiring high amounts of very inefficient e-fuels. Thus, in parallel to reducing the importance of private road transport, innovation of low-carbon solutions for aviation requires urgent attention, as well as a fair taxation on kerosene and carbon for this sector. Failure to do so in the coming decade will create risks of stranded assets in the future as aviation volumes would then need to be severely constrained.

**FIGURE 9. EVOLUTION OF ENERGY DEMAND BY TRANSPORT MODE (TWh)**
BUILDINGS

- Building policies need to ensure large energy efficiency improvements, together with heating decarbonisation.
- Renovation rates will need to at least double or triple, and these renovations will need to be carried out much more thoroughly. Deep renovation does not lead to an immediate return on investment, but it does bring many co-benefits, from increasing the quality of housing and therefore wellbeing, lowering energy costs and thereby reducing energy poverty and boosting employment in the construction sector. The European Commission can ensure that its Renovation Wave incentivises and provides financial mechanisms to achieve these deep renovation levels.
- Electricity consumption in this sector remains relatively stable while buildings can support the increase in variable renewable sources.
BUILDING POLICIES NEED TO ENSURE LARGE ENERGY EFFICIENCY IMPROVEMENTS, TOGETHER WITH HEATING DECARBONISATION

As a minimum, the pace of renovation needs to increase from less than 1% of the buildings stock today to at least 2.5% per year in the outlined scenarios, making this an absolute priority (Figure 11). This renovation rate must be reached over the next 12 years. In the 55% Shared Effort and 65% scenarios, the pace of renovation is such that all residential buildings would be renovated by 2048. In the 55% Technology-focused Scenario, 62% of the residential buildings would be renovated by 2050.

At the same time, all three modelled scenarios show that the depth of these renovations must increase over time to reach a “factor 4” renovation level for each renovated house, where insulation and other techniques reduce the energy consumption by ~75% after refurbishments. This will make heating decarbonisation manageable and avoid relying too much on biomass and electricity during winter. The mainstreaming of this average level of renovation will require significant innovation and industrialisation, and must also be reached within 12 years, by 2032.

Eventually this renovation would lead to a decrease of the space heating energy consumption for residential buildings by 2050 of 50% for the 55% Technology-focused Scenario and about 70% for the 55% Shared Effort and 65% scenarios (see Figure 11).

Many EU examples have demonstrated that deep renovation is now technically possible. However, policies relying only on step-by-step approaches will not deliver such depth of renovation and will need to trigger tremendously high amounts of investment (to compensate lower renovation depth with more renovations). Renovation policies should incentivise a unique one-stage approach whenever possible, in particular when buildings reach their key lifetime milestones (property transfers, rental cycles etc). Keeping in mind that one of the main barriers is unlocking investment, renovation must be supported by incentives and norms such as adequate performance standards, quality information based on energy audits and monitoring, training of the sector and financial innovation.
Benefits of ambitious renovation strategies for buildings are increasingly recognised, for example in terms of air quality or local job creation, as witnessed by the renovation strategies of EU states (see for example Table 11).  

Full heating decarbonisation, coupled with efficiency improvements, is achieved by 2050 in the 55% Technology-focused Scenario (Figure 12). For the 55% Shared Effort and 65% scenarios, heating still relies slightly on fossil fuels in 2050 (gas represents 2% and 10.4% of total energy consumption for the 55% Shared Effort Scenario and the 65% Scenario, respectively; oil represents 2.5% and 3.4% of total energy consumption for the 55% Shared Effort Scenario and 65% Scenario, respectively). This requires a steady pace of transformation and will need to leverage the full range of options depending on technical constraints (among others: heat pumps, geothermal, district heating, solar thermal and biomass or biogas to a limited extent) and to address financial barriers.

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**FIGURE 11. SPACE HEATING ENERGY CONSUMPTION FOR RESIDENTIAL BUILDINGS BY BUILDING CATEGORY [TWh/YEAR]**

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FIGURE 12: TOTAL ENERGY CONSUMPTION FOR RESIDENTIAL BUILDINGS BY TYPE OF FUEL [TWh/YEAR]

FIGURE 13: TOTAL ENERGY CONSUMPTION FOR RESIDENTIAL BUILDINGS BY TYPE OF USE [TWh/YEAR]
While both energy efficiency improvement and heating decarbonisation must be deepened much beyond today’s levels, more focus can be given to either one or the other, with varying implications on other sectors such as power and industry, for example:

- Electricity demand from buildings will only remain stable if energy efficiency options are sufficiently activated (typically aligned with the ~75% depth objective)
- Increased renovation activity and demand for new buildings will increase the need for materials which can lead to higher emissions in the short term from industrial sectors (reflecting part of the so-called embodied emissions).

Table 7 gives a short description of the ambition levels required for the main levers in the building sectors and how they differ across the three scenarios.

**TABLE 7: LEVELS OF CHANGE REQUIRED FOR THE KEY LEVERS IN BUILDINGS FOR THE THREE SCENARIOS**

<table>
<thead>
<tr>
<th>Residential Lever</th>
<th>55% Technology-focused Scenario</th>
<th>55% Shared Effort Scenario</th>
<th>65% Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand for heated areas</td>
<td>Compactness</td>
<td>The yearly evolution is decreased down to +0.35%/year by 2030 leading to an average floor area per person of 41.5m²/person</td>
<td>The yearly evolution is decreased down to 0 by 2026 and further reduced to -0.18%/year by 2030. The average floor area per person reaches 40.2m²/person</td>
</tr>
<tr>
<td>Envelope and heating efficiency</td>
<td>Renovation depth</td>
<td>Energy renovation is boosted such that it reaches 1.8%/year by 2025 with an average 35% Energy Efficiency, and 2.3% renovation by 2030 with an average 80% energy saving</td>
<td>Energy renovation is boosted such that it reaches 2.4%/year by 2025 with an average 35% Energy Efficiency, and 3.4% renovation rate by 2030 with an average 81% energy savings.</td>
</tr>
<tr>
<td></td>
<td>Demolition rate</td>
<td>A demolition rate of 0.22% is reached by 2026.</td>
<td>A demolition rate of 0.22% is reached by 2027.</td>
</tr>
<tr>
<td>Heat decarbonisation</td>
<td>Decarbonising heat</td>
<td>The share of fossil fuels used to heat existing buildings is reduced by 20% leading to a contribution of 47% by 2030. Heat is fully decarbonised by 2050.</td>
<td>Same actions as for the 55% Technology-focused Scenario.</td>
</tr>
<tr>
<td>Appliances &amp; consumer goods</td>
<td>Appliance utilisation</td>
<td>Demand for electricity-dependent services increases with 1%/year, reaching a demand 16% higher in 2030 than in 2015. Energy efficiency is improved by 36% by 2030.</td>
<td>Demand for electricity-dependent services reduces by 0.4%/year, reaching a demand 5.6% lower in 2030 than in 2015. Energy efficiency is improved by 36% by 2030.</td>
</tr>
<tr>
<td></td>
<td>Appliance standards</td>
<td>Demand for electricity-dependent services reduces by 0.4%/year, reaching a demand 5.6% lower in 2030 than in 2015. Energy efficiency is improved by 36% by 2030.</td>
<td>Demand for electricity-dependent services reduces by 0.4%/year, reaching a demand 5.6% lower in 2030 than in 2015. Energy efficiency is improved by 36% by 2030.</td>
</tr>
</tbody>
</table>

The yearly evolution of (m²/ person) is decreased down to 0.5%/year by 2030.

Energy renovation is boosted such that it reaches 2025 1.9%/year with an average 73% EE, and by 2030 2.5% renovation rate with an average 82% energy saving

A demolition rate of 0.22% is reached by 2026.
ELECTRICITY CONSUMPTION REMAINS RELATIVELY STABLE WITH AN INCREASE IN VARIABLE RENEWABLE SOURCES

In 2030, thanks to deep and fast renovation, residential buildings will require from 2,397 TWh (for the 55% Shared Effort Scenario) to 2,580 TWh (for the 55% Technology-focused Scenario), representing a decrease ranging from -5% to -11% compared to 2015 (see Figure 14). Electricity demand for residential buildings would decrease by 22% (55% Technology-focused), 28.6% (55% Shared Effort), and 22.9% (65% Scenario). This electricity consumption is expected to remain relatively stable in the longer term (see Figure 12 for residential buildings). Energy consumption in non-residential buildings would follow a comparable evolution.

But the electricity mix is fundamentally changing in these scenarios, with 60% (55% Technology-focused), 54% (55% Shared Effort), 54% (65% Scenario) of the 2030 supply generated by solar and wind (see Figure 2).

Buildings have a role in the deployment of renewable power production sources. On the one hand, new and renovated buildings can significantly contribute to the deployment of solar PV production. On the other hand, the deployment of smart technologies in energy-efficient buildings can provide part of the flexibility solutions needed for greater penetration of variable renewable sources.

![Figure 14: Energy Demand for Residential Buildings by Type of Fuel [TWh]](image)
• All scenarios clearly demonstrate that EU industry must seize the opportunities of the circular and functional economy (where assets are rented, leased or shared, substituting ownership), to achieve net-zero emissions by 2050 at the latest.

• This new economy can help increase the potential added value for EU products, but it requires a multi-sectoral vision and a just transition.

• The three scenarios offer different ways to align the industry with the right trajectory of GHG reduction by 2030 but any industrial roadmap targeting net-zero emissions by 2050 requires early action, investments and R&D.
All scenarios demonstrate that EU industry must seize the opportunities of the circular and functional economy.

Key findings of the three scenarios are detailed in the table below, highlighting no-regret actions for the sector which are highly interconnected. As an example, the ability to produce steel through secondary processes (e.g. electric furnaces) is related to creating the framework for better secondary material collection and separation processes.

**TABLE 8. LEVELS OF CHANGE REQUIRED FOR THE KEY LEVERS IN THE INDUSTRY**

<table>
<thead>
<tr>
<th>Sub-sector</th>
<th>Lever</th>
<th>55% Technology-focused</th>
<th>55% Shared Effort</th>
<th>65% Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product design</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material switch</td>
<td>A major material switch is undertaken: in road vehicles, 16% of steel is replaced by carbon fibres and 16% by aluminium. In buildings, 17% of cement is replaced by plastics, 16% of cement by timber and 41% of steel by timber.</td>
<td>Same as for the 55% Technology-focused Scenario for the three levers.</td>
<td></td>
<td>Innovation allows going a bit further than the 55% scenarios:</td>
</tr>
<tr>
<td>Material intensity of products</td>
<td>The improved design and the use of more efficient materials enables reducing the material use per product by 10% in steel, 20% in high value chemicals (HVC), 10% in cement, and 8% in other industries.</td>
<td></td>
<td></td>
<td>In transport, 18% of steel is replaced by carbon fibres and 18% by aluminium.</td>
</tr>
<tr>
<td>Share of recycled materials</td>
<td>The share of recycled materials in new products increases to 65% for steel, 14% for HVC, 75% for cement, and 50% for the other industries.</td>
<td></td>
<td></td>
<td>In buildings, 18% of cement is replaced by plastics, 18% of cement by timber and 18% of steel by timber.</td>
</tr>
<tr>
<td><strong>Processes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New process technologies</td>
<td>Maximum ambition is required for all modelled action lever</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy efficiency</td>
<td>New technologies are deployed: 27% of primary steel is manufactured through HISarna, 18% of primary cement is manufactured through polymers. Wet clinker is entirely substituted with dry clinker.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrification</td>
<td>Within existing technologies, energy efficiency is improved by 28% to produce clinker, 18% for chemicals production (average for all chemicals modelled) and 9% for steel BOF process.</td>
<td></td>
<td></td>
<td>Processes are further electrified, assuming a major use of resistive heating. 50-70% of fossil fuels are substituted by electrification in steel, chemicals and other smaller industries.</td>
</tr>
<tr>
<td>Fuel switch</td>
<td>Processes are further electrified, assuming a major use of resistive heating. 50-70% of fossil fuels are substituted by electrification in steel, chemicals and other smaller industries.</td>
<td></td>
<td></td>
<td>Fuel switches are slightly lower than for the 55% Technology-focused and 65% scenarios. First, of the remaining coal and oil, 27% are replaced by gas in HVC and 24% by hydrogen in traditional steel (BOF). Second, of the remaining fossil fuels, 51% is replaced by hydrogen in ammonia production and 24% in other chemicals manufacturing. Third, remaining fossil fuels are substituted at 15% by biomass in oxygen steel, 24% in chemicals (HVC, ammonia), 84% in cement, and 65% in other materials.</td>
</tr>
<tr>
<td><strong>CCS</strong></td>
<td>24 MtCO2 are capture in 2030 to support several sectors (steels, HVC, ammonia, cement and others)</td>
<td>~7 MtCO2 are capture in 2030 for the same sectors.</td>
<td>17 MtCO2 are capture in 2030 for the same sectors.</td>
<td></td>
</tr>
</tbody>
</table>

33 HVC = high Value Chemicals
34 These shares exclude the manufacturing waste recycling flows
35 These shares exclude the manufacturing waste recycling flows
36 BOF = Blast Oxygen Furnaces.
THE CIRCULAR ECONOMY AND THE FUNCTIONAL ECONOMY CONSTITUTE A SIGNIFICANT POTENTIAL ADDED VALUE FOR EU PRODUCTS

A clear shift towards a profoundly circular and functional economy is needed before 2050 to stay aligned with the Paris Agreement goals and the European Commission’s Green Deal. EU industry can take appropriate action in all sectors to avoid staying locked in carbon-intensive assets.

Such a transition substantially improves the lifecycle of assets from design, materials, production, and use to end-of-life. This represents an opportunity to increase the added value of products thanks to longer lifetimes and higher utilisation rates as well as the value of maintenance services. The circular and functional economy reduces the industry’s dependency on virgin raw materials and complex supply chains, enhancing the EU’s resilience in the face of international crises.

The competitiveness of the industry could also benefit when meeting the required R&D challenges:

- To shift away from carbon-intensive materials (e.g. substituting steel with carbon fibres or aluminium, replacing a share of the cement by timber in buildings);
- To improve product design with regard to materials intensity;
- To increase the share of recycled materials;
- To improve the efficiency of processes;
- To electrify and switch to alternative fuels such as hydrogen (H2) when possible; and
- To start introducing carbon capture and storage capacity before 2030.

THE TRANSITION TO CIRCULAR AND SHARING ECONOMIES REQUIRES A MULTI-SECTORAL VISION AND A JUST TRANSITION

By definition, the circular economy builds upon relations between sectors, typically when waste or by-products of one sector are the input materials of another. Policies to support the required industry shift consequently need to encompass various sectors in a coherent way.

The industrial evolution is different in each scenario with regard to improvement of materials and processes as well as the time needed to achieve them. This illustrates policy trade-offs. The sooner the EU economy becomes more circular and enhances sharing, the more the EU will harvest its potential, but the shorter transition period requires sufficient and just support.

As an illustration, in the 55% Technology-focused Scenario, heavy industry is put on the right climate trajectory thanks to an early deployment of technologies, including carbon capture and storage, with the drawback of exploiting circularity less. In addition, a large manufacturing base is maintained until 2030, and the industrial transformation is strongly focused on improving industrial production processes and starting to deploy carbon capturing and storing technologies before 2030. Demand for materials and products in 2030 is therefore not significantly reduced compared to today (10%, see Figure 16). This requires investment and infrastructure deployment, for example for carbon capture and storage or hydrogen (H2), to be supported by appropriate policies. In this scenario, carbon capture and storage deployment typically generalises the Netherlands’ current engagement to capture 7 MtCO2 in 2030.
In contrast, the 55% Shared Effort and the 65% scenarios profoundly shift to circular and functional economies and rely on increased demand-side measures. This lowers the demand for new products such as vehicles or building materials (-31% production in 2030 compared to 2020 for the 55% Shared Effort Scenario and -43% in the 65% Scenario).

ANY INDUSTRIAL ROADMAP TARGETING NET-ZERO EMISSIONS BY 2050 REQUIRES EARLY ACTION, INVESTMENTS AND R&D

With investment decisions imminent in any case over the next decade in most energy-intense companies, policy-makers can guide support investments at the scale needed to put industry on a net-zero pathway for 2050 and higher emissions reductions by 2030. Industry can avoid incremental changes over the next decade which would require drastic and unprecedented emissions reductions between 2030 and 2050. The EU’s new industrial policy strategy and policy actions towards the circular economy are an opportunity to ensure that conditions are set to shift industries into fully-fledged low-carbon production.

All the scenarios show that the next 10 years are key to setting the industry on the right transformation path, with zero-carbon innovation kicking in even more strongly after 2030. More precisely, the two 55% scenarios plan a 25-year transition period until the sector reaches its required emissions reduction, from 2020 to 2045. Such a trajectory (see Figure 17 for the 55% Technology-focused Scenario) requires anticipation and preparation to be managed well.

In the 65% Scenario, industry accelerates its transition towards circular and sharing economies. The industry R&D challenges must be solved by 2040, five to ten years earlier than in the 55% Technology-focused Scenario. Both in the 55% Shared Effort and in the 65% scenario, transformational changes in transport and buildings together lead to significant reduction of materials production needs (-43% in 2030 compared to 2015, see Figure 16).
## INCREASING THE EU’S 2030 EMISSIONS REDUCTION TARGET

### FIGURE 16. MATERIAL PRODUCTION IN CIRCULAR AND FUNCTIONAL ECONOMY, INCLUDING EXPORT [Mt OF MATERIALS/YEAR]

<table>
<thead>
<tr>
<th>Technology-focused</th>
<th>Shared effort</th>
<th>2030 Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>2010</td>
<td>2015</td>
</tr>
<tr>
<td>STEEL</td>
<td>CEMENT</td>
<td>CHEMICALS</td>
</tr>
<tr>
<td>588</td>
<td>490</td>
<td>455</td>
</tr>
<tr>
<td>145</td>
<td>133</td>
<td>127</td>
</tr>
<tr>
<td>258</td>
<td>181</td>
<td>156</td>
</tr>
<tr>
<td>137</td>
<td>134</td>
<td>132</td>
</tr>
<tr>
<td>48</td>
<td>42</td>
<td>39</td>
</tr>
</tbody>
</table>

### FIGURE 17. TOTAL ENERGY CONSUMPTION BY THE INDUSTRY [TWh]

<table>
<thead>
<tr>
<th>Technology-focused</th>
<th>Shared effort</th>
<th>2030 Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>2010</td>
<td>2020</td>
</tr>
<tr>
<td>STEEL</td>
<td>CEMENT</td>
<td>CHEMICALS</td>
</tr>
<tr>
<td>3.437</td>
<td>2.960</td>
<td>2.949</td>
</tr>
<tr>
<td>686</td>
<td>554</td>
<td>511</td>
</tr>
<tr>
<td>247</td>
<td>252</td>
<td>185</td>
</tr>
<tr>
<td>591</td>
<td>533</td>
<td>560</td>
</tr>
<tr>
<td>1,913</td>
<td>1,621</td>
<td>1,693</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,693</td>
</tr>
</tbody>
</table>

### 2030 Scenarios

- Technology-focused: -12%, -16%, -29%
- Shared effort: 55%
- Other industries: 65%
In the 55% Technology-focused Scenario, the deployment of carbon capture and storage and H2 technologies starts as early as possible in order to reach the necessary reductions by 2030. Any postponement will put a very high burden on the demand side or require drastic emissions reductions after 2030. The 55% Technology-focused Scenario relies on ~24 Mt CO2 being captured and stored in 2030. This again implies appropriate policies to support these significant investments. In contrast, the 65% Scenario requires 17 MtCO2 in 2030 and the 55% Shared Effort Scenario only ~7 MtCO2.

The fuel shift in industry will increase its electricity consumption but its total energy demand will be lower than today’s level thanks to combined improvements in the efficiency of processes and the circularity of products. The more a scenario relies on technological solutions, the more energy is required. A minimum of a 12% reduction of the total energy consumption is envisaged in all three scenarios in 2030 compared to 2015 (see Figure 18).

In many industrial decarbonisation scenarios, technologies with substantial emissions reduction potential, such as carbon capture and storage, only increase significantly after 2030 and are widely deployed in 2050. The findings of this report suggest that policies should channel the appropriate R&D support to ensure that these technologies reach a sufficient Technology Readiness Level (TRL) already by 2030.
POWER

• Power decarbonisation has to accelerate even more, with fossil fuel use significantly reduced by 2030.
• Solar and wind deployment rates will need to at least double or triple and coal will largely be phased out by 2030.
• Leaving the coal phase-out to later than 2030 makes it impossible to cut emissions at the pace required to meet the temperature goals of the Paris Agreement.
• Gas demand is also at least cut in half by 2030 (compared to the 2019 level) in all scenarios, so it will be important to minimise any new investment in gas infrastructure, which would become a stranded asset in the future.
• Demand-side measures can help reduce gas and renewable energy uptake.
Decarbonising energy supply—mostly power production and refining—is essential in reaching higher EU climate targets. GHG emissions from the power sector in the EU accounted for 28% of total emissions in 2017 and while they fell 12% in 2019, they remain one of the largest emitting sectors in Europe. Power sector emissions went down by -32% in 2019 compared to 2012 due to a decrease in coal and increase in renewable energy production. This increase in renewable energy sources has recently slowed though, going from about +16% between 2010 and 2017 to only +6.5% in 2018 and +5.5% in 2019. Key components across all scenarios are the deployment of renewable energy and a coal phase-out by 2030.

### Table 9. Levels of Change Required for the Key Levers in the Power Sector

<table>
<thead>
<tr>
<th>Subsector</th>
<th>Lever</th>
<th>55% Technology-focused Scenario</th>
<th>55% Shared Effort</th>
<th>65% Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity production</td>
<td>Coal phase-out</td>
<td>Coal is almost fully phased out by 2030, going from 470 TWh in 2019 to 50 in 2030 (~10% of 2019)</td>
<td>Coal is almost fully phased out by 2030, going from 470 TWh in 2019 to 41 TWh (Shared Effort) and 25 TWh (65%) in 2030 (~5% of 2019)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>This then decreases further to 31 TWh in 2040 and 11 TWh in 2050.</td>
<td>This then decreases further to 0 by 2040.</td>
<td></td>
</tr>
<tr>
<td>RES support</td>
<td></td>
<td>RES production covers 75% of the power production by 2030.</td>
<td>RES production covers 75% of the power production by 2030, but on a lower total production than in the 55% Technology-focused Scenario. This means RES has a lower growth of 8.5% year-on-year in the 65% Scenario, adding about 90 TWh per year in the next 10 years. The RES share also increases to 92% by 2050.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>This means RES has a 12% growth year-on-year in the 55% Technology-focused Scenario, adding about 130 TWh of production per year in the next 10 years compared to ~40 TWh from 2010 to 2018. The RES share increases to 92% by 2050.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuclear</td>
<td></td>
<td>Nuclear slowly phases out, contributing 17% of production mix in 2030, and just 2% by 2050.</td>
<td>Nuclear slowly phases out at the same speed as in the 55% Technology-focused Scenario, contributing ~20% of production mix in 2030, and just 2% by 2050.</td>
<td></td>
</tr>
<tr>
<td>Hydrogen</td>
<td></td>
<td>Hydrogen-based production (based on electrolysis) slowly starts in 2030, covering 6% of production in 2050</td>
<td>Hydrogen-based production (based on electrolysis) slowly starts in 2030, covering 5% of production in 2050</td>
<td></td>
</tr>
<tr>
<td>Biomass contribution</td>
<td></td>
<td>Biomass-based production stays roughly stable with 186 TWh in 2030</td>
<td>Biomass-based production stays roughly stable with 186 TWh in 2030</td>
<td></td>
</tr>
<tr>
<td>CCS</td>
<td></td>
<td>No CCS is assumed in power</td>
<td>No CCS is assumed in power</td>
<td></td>
</tr>
<tr>
<td>Intermitency and Demand Side Management (DSM)</td>
<td>Zero-carbon flexibility options</td>
<td>Variable renewable energy source production reaches 59% by 2030 and 80% by 2050. This is capped by the available network flexibility.</td>
<td>Variable renewable energy source production reaches 55% by 2030 and 74% by 2050. This is capped by the available network flexibility.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The focus for flexibility solutions is on natural gas dispatchable capacity</td>
<td>100% of the demand-side management potential is captured from 2030 onwards. Several zero-carbon flexibility options cover the daily and weekly flexibility needs (storage, interconnections, biomass-firing). Seasonal flexibility is answered by zero-carbon dispatchable generation.</td>
<td></td>
</tr>
</tbody>
</table>

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37 See the Agora Energiewende publication (2020): The European Power Sector in 2019: Up-to-Date Analysis on the Electricity Transition
FOSSIL FUEL USE NEEDS TO BE SIGNIFICANTLY REDUCED BY 2030

The decrease in coal-based production has been particularly strong with a 47% drop between 2012 and 2019 (of which 24% just this last year). 38 74 GW of coal power capacity has been closed since 2010 and 73 GW or 48% of remaining capacity is located in countries which have announced they will phase out coal by 2030 or earlier. 39 Six countries in the EU are now coal-free and 14 have pledged to become coal-free by 2030 or earlier. 40 Germany has pledged to phase out only in 2038. Coal phase-out discussions are still ongoing in the Czech Republic, while Bulgaria, Croatia, Poland, Slovenia and Romania have no national coal phase-out dates yet. Reaching -55% or -65% by 2030 requires these last countries to support an adequate phase-out hand in hand with a just transition.

Given coal’s high carbon emissions, an almost complete coal phase-out by 2030 makes 55% or 65% GHG emissions reductions achievable. The 55% Technology-focused Scenario assumes coal reduces 10-fold from 470 TWh to 49 TWh in 2030. The 55% Shared Effort and 65% scenarios go further down to 41 and 25 TWh, respectively, with coal playing a back-up role rather than that of a baseload supply.

The levels of coal generation currently being proposed for 2030 in Germany and Poland will significantly exceed the levels required in the outlined scenarios. While other countries also clearly matter (notably the Czech Republic, Romania and Bulgaria), the two largest coal-based producers should consider a coal phase-out by 2030 in order to avoid additional efforts by other sectors. Given higher CO2 prices are expected with the upcoming strengthening of the EU Emissions Trading Scheme, coal will become even less cost-competitive.

The closure of coal powerplants must be coupled with sufficient investments into and deployment of renewable energy to avoid new gas power plants filling the potential gap between supply and demand. This would only reduce emissions roughly by half compared to emission-free renewable energy sources and lock in fossil fuel infrastructure, turning into stranded assets in the 2030s.

ONLY RENEWABLE ENERGY SOURCES ALLOW FOR COST EFFECTIVENESS

Shifting from coal to gas will not be sufficient to achieve the necessary emissions reductions. Better alternatives are wind and solar and they should grow 12% year-on-year in the 55% Technology-focused Scenario. This is not higher than historic growth since 2010 but it is starting from a much higher base, therefore adding about 25 TWh (in the 55% Shared Effort and 65% scenarios) to 130 TWh (in the 55% Technology-focused Scenario) of production per year over the next 10 years compared to ~40 TWh from 2010 to 2018.

The growth of renewable energy will define directly the reduction of gas production and related GHG emissions reductions. The 55% Technology-focused Scenario shows a share of renewable energy source production of 72% in 2030, 60% of which just wind and solar PV (see Figure 18). The development of renewable energy sources is expected to grow further at a comparable pace after 2030 as the demand for electricity in other sectors, including for the production of green hydrogen, continues to increase.

The uptake in the 55% Shared Effort and 65% scenarios are lower as additional demand-side changes lead to a 10% reduction in power demand, but still requires more than doubling the amount of wind and solar power production.

38 See the Agora Energiewende publication (2020): The European Power Sector in 2019: Up-to-Date Analysis on the Electricity Transition
39 Europe Beyond Coal: Overview: National coal phase-out announcements in Europe Status April 2020
40 See the Agora Energiewende publication (2020): The European Power Sector in 2019: Up-to-Date Analysis on the Electricity Transition
41 Ibid.
Austria, Denmark and Sweden are already in the 70% renewable energy source range, and several other countries are now in the 30 to 50% range (Croatia, Finland, Germany, Ireland, Italy, Latvia, Portugal, Romania, Slovenia, Spain and the UK), with a total share of 35% renewable energy source-based electricity production in the EU in 2019 (Figure 19).

**FIGURE 18. ELECTRICITY GENERATION MIX BY SCENARIO [TWh]**

**FIGURE 19. SHARE OF RENEWABLE ENERGY SOURCES IN TOTAL ELECTRICITY GENERATION IN EUROPEAN COUNTRIES AND EU AVERAGE.**

*COURTESY OF SANDBAG AND AGORA ENERGIEWENDE*
This shift towards renewable energy sources must take into account the variability of wind and solar. All flexibility options must continue to shift into higher gear, with more power grid interconnection, higher demand-side flexibility, more storage and back-up alternatives. The power sector is already stepping up to the challenge, but efforts must be increased.

DEMAND-SIDE MEASURES CAN HELP REDUCE GAS AND RENEWABLE ENERGY UPTAKE

Behaviour and societal change across the various sectors in the 55% Shared Effort and 65% scenarios allow for the reduction of ambition on the technological front, for example on renewable deployment.

In this case lower demand in 2030 leads to lower growth in solar and wind production, to 1,352 and 1,359 TWh for the 55% Shared Effort and 65% scenarios respectively, more easily replacing gas-based production which decreases from 365 to 25 and 29 TWh for the 55% Shared Effort and 65% scenarios respectively (see Figure 18).

In the 65% Scenario, the trend is reinforced after 2030 with lower demand in 2050 (~2700 TWh) than for the 55% Shared Effort Scenario (~3500 TWh) and the 55% Technology-focused Scenario (~5800 TWh).

**FIGURE 20. ELECTRICITY DEMAND IN THE THREE SCENARIOS [TWh]**
FIGURE 21: ELECTRICITY GENERATION MIX EVOLUTION FROM 2005 TO 2050 FOR THE THREE SCENARIOS [TWh]
The EU can no longer ignore the role of agriculture and land use in relation to reducing GHG emissions. Policy-makers should therefore urgently explore pathways that tackle this major driver of emissions while taking into account both the changes in farming and the co-benefits for biodiversity.

By 2030, agricultural emissions are reduced by at least 25% (compared to 2015) in all the three studied scenarios.

Diets are key drivers for reducing agricultural emissions and improve health, and the 65% Scenario is better aligned with WHO health recommendations. Also, if diets are not improved, technical measures will be required to make agriculture more productive, raising sustainability risks.

Land use drives the potential to naturally capture CO2 in the next decades, and there will be significant changes: in all three scenarios, surplus land is converted into grasslands and forests to reach net-zero by 2050 at the latest, and forests would increase their cover from about 40% today to ~50% of the EU area by 2030.

These land-use changes also drive the availability of residues and by-products from agriculture and forestry for sustainable bioenergy.

Land-requiring bioenergy crops are phased out by 2030 or shortly after in all three scenarios.
AGRICULTURE AND LAND USE NEED A PATHWAY TO CONTRIBUTE TO NET-ZERO GHG EMISSIONS

The agricultural sector represented a significant share of EU emissions in 2015 with ~460 MtCO2e or 12% of total GHG emissions (when including CO2 emissions from energy consumption in this sector). Natural sinks formed through land use, land-use change and forestry (LULUCF) on the other hand contributed to a reduction of 295 MtCO2e, a capture of ~7% of the emissions. If properly managed, natural sinks can remove some remaining emissions in the future and will be essential to reach net-zero ambition by mid-century at the latest44.

By 2030, agricultural emissions are reduced by at least 25% (compared to 2015) in all the three studied scenarios (and by at least 39% compared to 1990). Several options exist to reduce emissions, including improvement of diet and food waste, land-use and agricultural practices. Changing diet impacts both the agricultural production and land required, which significantly drive the sector’s GHG emissions.

The scenarios clearly highlight the trade-off between changing the demand for agricultural products and increasing agricultural efficiency. If diets are not improved by shifting to more vegetable-based protein sources and less meat (less ruminant meat in particular), technical measures will be necessary to significantly increase yields both for crops and livestock production, with as a drawback increased emissions from chemical fertilisers and other risks (increased costs, pressure on biodiversity etc).

NO-REGRET ACTIONS ARE IDENTIFIED ACROSS THE THREE SCENARIOS

Irrespective of the chosen scenario, a minimum improvement of diet and agricultural efficiency is required (see Table 10). To reach a 55% emissions reduction in 2030, at least 11% of the meat consumption is replaced by domestic vegetable protein sources (as in the 55% Technology-focused Scenario, see Figure 23) and crop yields are increased by at least 13% compared to 2015 (as in the 55% Shared Effort Scenario).

This study has identified two crucial no-regret actions. First, a maximum effort is necessary to reduce food waste (and meat waste in particular) all along the supply chain, from farm to consumer waste. In the case of meat, this means collecting more than 50% of post-farm waste by 2030 (compared to 40% in 2015).

Second, land multi-use is improved in all three scenarios. Multi-use means either simultaneously sharing land for different compatible sustainable uses (e.g. pasture and fruit trees) and/or having more frequent crop rotations per year. For a fixed production level, sharing land leads to sparing land. The scenarios typically reach an agricultural land requirement reduction of ~17% in 2030 (going towards ~30% in 2050). Agroecology is a good example of land multi-use, showing how emissions reductions can be also coupled with ecosystems restoration.

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44 Even though the 2030 targets discussed in this report, 55% and 65%, are defined without encompassing the carbon removals by LULUCF.
The table here below sums up the key implications of the three scenarios for the sector.

**TABLE 10. LEVELS OF CHANGE REQUIRED FOR THE KEY LEVERS IN AGRICULTURE AND LAND USE**

<table>
<thead>
<tr>
<th>Subsector</th>
<th>Lever</th>
<th>55% Technology-focused</th>
<th>55% Shared Effort</th>
<th>65% Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diets</strong></td>
<td>Change diets</td>
<td>Diet must become healthier: calories consumption in 2030 are comparable to 2015 level (-1%), but the meat consumption per person is reduced by 11%, while the dairy products consumption is stabilised at 2015 level. The share of ruminant meat decreases to around 19% of the consumed meat (vs20% in 2015). Production of dairy products is also stabilised to 2015 levels.</td>
<td>Total calories are reduced by 4% (2030 vs 2015)</td>
<td>Meat quantities are reduced by 28% (2030 vs 2015)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The share of ruminant meat still represents 18% of the meat quantity</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Production of dairy products is also stabilised to 2015 levels.</td>
</tr>
<tr>
<td></td>
<td>Talent diets</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Agricultural practices</strong></td>
<td>Reduce food waste</td>
<td>Maximum potential of waste collection is achieved: ~20% on-farm food crops waste and 50% of post-farm meat waste are collected (vs 10% on-farm and 40% meat post-farm in 2015)</td>
<td>Same as in 55% Technology</td>
<td></td>
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<tr>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>Increase crops yields</td>
<td>Crops yields increase by 17% in the same period while minimising the use of nitrous fertilisers.</td>
<td>Crops yields are less increased compared to the 55% technology: +13% in 2030 vs 2015</td>
<td>Crops yields are less increased compared to the 55% Technology: +13% in 2030 vs 2015</td>
</tr>
<tr>
<td><strong>Land use</strong></td>
<td>Slow down land degradation</td>
<td>Maximum effort is made to stop land degradation.</td>
<td>Maximum effort is made to stop land degradation.</td>
<td>Maximum effort to prevent land degradation</td>
</tr>
<tr>
<td></td>
<td>Land multi-use</td>
<td>17% less land is required to produce food thanks to multi-cropping and other changes in agriculture practices (2030 versus 2015).</td>
<td>17% less land is required to multi-use practices (2030 versus 2015).</td>
<td>17% less land required thanks to multi-use</td>
</tr>
<tr>
<td></td>
<td>Use of surplus land</td>
<td>78% of all surplus land is afforested and 22% is dedicated to grasslands.</td>
<td>Similar land decisions as in the 55% technology.</td>
<td>80% of surplus land is afforested and 20% converted to grasslands</td>
</tr>
<tr>
<td></td>
<td>Forestry intensity</td>
<td>The forest harvesting intensity is lowered by ~12% (2030 versus 2015) corresponding either to an average intensity reduction or the set-aside preservation of 12% of EU forests. The 2030 demand for sustainable bioenergy is met.</td>
<td>Similar to 55% Technology</td>
<td>Forest intensity is reduced by ~13% compared to 2015 level. This again can be either a generalised practice or a set-aside.</td>
</tr>
<tr>
<td></td>
<td>Dedicated bioenergy crops</td>
<td>Less than 3 Mha\textsuperscript{1} dedicated biofuel/energy crops are necessary; this is about a third of 2015 dedicated crops.</td>
<td>Same as in the 55% Technology, less than 3 Mha dedicated biofuel/energy crops</td>
<td>No dedicated crops are necessary in this scenario.</td>
</tr>
<tr>
<td><strong>Bioenergy</strong></td>
<td>Total bioenergy demand (vs 2015)</td>
<td>+5%</td>
<td>+1%</td>
<td>+5%</td>
</tr>
<tr>
<td></td>
<td>Liquid biofuel demand (vs 2015)</td>
<td>-17%</td>
<td>-16%</td>
<td>-51%</td>
</tr>
</tbody>
</table>
DIETS ARE KEY DRIVERS FOR REDUCING AGRICULTURAL EMISSIONS AND IMPROVE HEALTH

It is widely recognised that our diets should include less meat to improve our health. The WHO for instance recommends halving the European’s average meat consumption. Food consumption, and livestock-based products particularly (i.e. bovine meat and dairy products), constitute a key driver of agricultural emissions.

THE 65% SCENARIO IS BETTER ALIGNED WITH WHO HEALTH RECOMMENDATIONS

As depicted on Figure 22 this scenario leads to a 32% meat substitution by vegetable protein alternatives in 2030 compared to the 2015 level and a stabilisation of dairy products. The 55% Shared Effort Scenario reduces meat consumption by 28%. Reducing meat consumption may come from either an evolution of socio-cultural habits or by agri-food innovation (think about meat-free burgers for instance or the Food-as-Software model.46 In such scenarios, the EU would be on the right trajectory to reach the WHO target level.

FIGURE 22. FOOD CONSUMPTION, INCLUDING 9% NET EXPORT, IN THE 55% AND 65% SCENARIOS COMPARED TO THE HISTORICAL MEAT CONSUMPTION TREND [kCAL/CAPITA.DAY]

IF DIETS ARE NOT IMPROVED, TECHNICAL MEASURES WILL BE REQUIRED TO MAKE AGRICULTURE MORE PRODUCTIVE, RAISING SUSTAINABILITY RISKS

Limited changes in diet obviously require other actions to reduce emissions in the sector. This includes reaching a high level of efficiency in agricultural processes, for example by increasing yields when possible without harming biodiversity, improving energy efficiency. Such technical measures could however deviate from the new European Commission “From Farm to Fork” strategy, having among other 2030 targets the reduction by 50% of the use and risk of chemical pesticides and reducing fertiliser use by at least 20%.”47

46 See the RethinkX report: Rethinking Food and Agriculture 2020-2030
47 See the EC “From Farm to Fork Strategy” report (2020).
In the 55% Technology-focused Scenario, 11% of the meat is replaced by vegetable alternatives in 2030 compared to 2015 (see Figure 22). This is only slightly higher than the latest trends of decreasing meat consumption (~0.4% per year since 2000). The type of remaining meat is also shifted to a lower share of ruminant meat from 19% in 2015 to 16.7% in 2030 in this 55% Technology-focused Scenario. In the other scenarios, the production of dairy products is limited to the 2015 level, which contrasts with the growth trend for milk products observed over the last five to 10 years.

Note that all the three scenarios keep the food net-export ratios identical to the 2015 level, a net overproduction of 21% food (and 9% meat) compared to domestic consumption.

LAND USE DRIVES THE POTENTIAL TO NATURALLY CAPTURE CO2 IN THE NEXT DECADES

Land use is critical to capturing the uncompressible emissions from other sectors and to reaching the EU 2050 net-zero target. Land-use management encompasses a variety of mitigation measures, from societal organisation to technical measures.

LAND USES WILL SIGNIFICANTLY EVOLVE IN ANY 55% OR 65% SCENARIO

The EU 2030 targets are currently defined without encompassing emissions from international bunkers or removals from land use, land-use change and forestry (LULUCF). Changing agricultural production and practices impacts land use, and in particular the surface area dedicated to animals and feed crops is expected to decrease (see Figure 24). Freed-up land then can be exploited to expand permanent prairies and forest areas which play an important role when targeting net-zero emissions by 2050.

In the 55% Technology-focused Scenario a large focus is set on increasing the average EU agricultural productivity and land multi-use. This eventually leads to a 38% reduction of agricultural land in 2030 (see Figure 23). The change is comparable in the 65% Scenario where agricultural production is much more modified through lifestyle changes. The 55% Shared Effort Scenario requires less change of agricultural land.

In all three scenarios, this surplus land is mainly converted into forest to reach net-zero by 2050 at the latest. Forests would cover ~50% of the EU area by 2030 (to be compared to today’s ~39%) which, if adequately managed, would have many co-benefits beyond climate (biodiversity, landscapes improvement, recreational, wood availability, etc.).

FIGURE 23. LAND-USE [% OF LAND]

LAND USE ALSO DRIVES THE AVAILABILITY OF RESIDUES AND BY-PRODUCTS FROM AGRICULTURE AND FORESTRY FOR SUSTAINABLE BIOENERGY

Residues and waste from agriculture are currently underexploited and represent a source of sustainable feedstock for bioenergy. In all three scenarios, a better exploitation of these residues counterbalances the reduced agricultural production which maintains a potential for sustainable bioenergy. The massive expansion of forests, even when coupled with a softening of the harvesting intensity as in the three scenarios, guarantees the availability of some low-value coproducts from the wood industry which can be converted to bioenergy at the end of their life cycle.

Consequently, the total domestic potential of bioenergy in 2030 remains comparable to today’s level in all scenarios, though the type of feedstock progressively shifts to wastes and residues of lower added value compared to current sources.

FIGURE 24. BIOENERGY DEMAND BY TYPE [TWh]
DEMAND FOR SOLID AND GASEOUS BIOENERGY REMAINS STABLE

Only if domestic bioenergy potential is sourced sustainably from the residues from both agriculture and the wood industry that are considered in this report, can it reduce emissions in other sectors.\(^45\). **Supporting other sectors can be particularly important in 2030 as some key technologies won’t be deployed or available on a large scale at that time** (e.g. hydrogen, carbon capture, e-fuels). This is why the 55% Technology-focused and the 65% scenarios foresee a very limited increase of 5% in the demand for solid and gaseous bioenergy in 2030 (compared to 2015, see Figure 24). This is mainly driven by demand from industry (+23%), even though demand from this sector will stabilise if not reduce after 2035. The biomass demand for power generation is kept constant after 2020 and that of buildings decreases.

The bioenergy demand in the three scenarios clearly breaks with the historical trend (see Figure 25). As a consequence, the domestic demand for bioenergy does not exceed the domestic potential for sustainable biomass. This obviously requires ensuring the sustainability of the biomass used, otherwise it is completely counter-productive and can have a significant impact on biodiversity, in Europe and abroad. Strengthening biomass sustainability requires shifting from today’s feedstock mix to a larger proportion of agricultural and forestry residues.

LAND-REQUIRING BIOENERGY CROPS ARE PHASED OUT BY 2030 OR SHORTLY AFTER

The total demand for liquid bioenergy in transport is reduced by at least \(-10\%\) in 2030 compared to 2015 as a result of two balanced trends. On one hand, the liquid bioenergy need for shipping grows. On the other hand, this increase is more than offset by a lower demand for road transport.

The resulting demand can be met while phasing out land-requiring bioenergy: only about a third of the dedicated energy crops existing in 2015 should be maintained in 2030 to produce biofuels. These dedicated crops are progressively removed afterwards. The 65% Scenario does not require any dedicated crops by 2030.

Therefore, none of the scenarios require increasing the share of imported biomass. In all scenarios, no import for liquid bioenergy is needed in 2030 and maximum 4% of the solid and gaseous feedstock will be imported, compared to the average 4% import in 2015. This reduces sustainability risks since the domestic feedstock supply can be more transparently monitored.

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\(^45\) See the Climact report (2018): Net zero by 2050: from whether to how. Zero emissions pathways to the Europe we want.
The CTI 2050 Roadmap model (covering all the EU-28) and the EU-Calc (offering member states granularity) have been exploited to take the UK leave into account.

The overall assumption of this work is the UK will follow a pathway with an identical 2030 target (55% or 65%) and similar policy options (in terms of activating levers either on the technology or lifestyle sides). Scenarios for the UK therefore depict similar trends of emissions and energy compared to the EU-28 scenarios initially designed with the CTI model while adequately keeping the UK specificities of each sector. The EU-27 implications then were obtained by subtracting the UK scenarios from the CTI ones. Figure 25, Figure 26 and Figure 27 here below illustrate the results.

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**EU-28 55 SHARED EFFORT (EXCL. LULUCF)**

- Agriculture
- Buildings
- Cement
- Chemical
- Oil & Gas
- Other Industries
- Power Production
- Steel
- Transport (Excl. International Bunkers)
- Waste

**FIGURE 25. EMISSIONS OF THE EU-27 VS EU-28 IN THE 55% SHARED EFFORT SCENARIO [MtCO2e]**
FIGURE 26. EU-28 VS EU-27 IN THE 55% SHARED EFFORT SCENARIO: POWER GENERATION [TWh]

--- EU-28 55 SHARED EFFORT
- BIOMASS
- COAL
- GAS
- HYDRO AND OTHER RES
- OIL
- NUCLEAR
- HYDROGEN
- VARIOUS RES (WIND & SOLAR)

FIGURE 27. EU-27 VS EU-28 IN THE 55% SHARED EFFORT SCENARIO: MATERIAL PRODUCTION [MT/YEAR]

--- EU-28 55 SHARED EFFORT
- CEMENT
- CHEMICAL
- OTHER INDUSTRIES
- STEEL

-30%
-31%
-13%
-11%
-11%
-8%
KEY REFERENCES


JRC (2014). New study quantifies the effects of climate change in Europe. 2.


