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ENVE

Contribution of EU local and regional authorities to a successful implementation of the EU Long Term Strategy

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This report was written by Mariya Gancheva, Guillermo Gea, Matthew Jones, Sarah O'Brien and Tugce Tugran (Milieu Ltd, Belgium).

Table of contents

List of tables

List of figures

List of abbreviations

BAT	Best Available Technique
BECCS	Bio-Energy with Carbon Capture and Storage
BTR	Biennial Transparency Report
CAP	Common Agricultural Policy
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Utilisation
CLLD	Community-Led Local Development
COP	Conference of the Parties
CoR	European Committee of the Regions
EAP	Environment Action Programme
EE	Energy Efficiency
ETS	Emissions Trading System
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GR	Governance Regulation
HDV	Heavy-Duty Vehicle
IPCC	Intergovernmental Panel on Climate Change
LDCs	Least Development Countries
LDV	Light-Duty Vehicle
LRAs	Local and Regional Authorities
LTS	Long Term Strategy
LULUCF	Land Use, Land-Use Change, and Forestry
NDC	Nationally Determined Contribution
NECP	National Energy and Climate Plan
PAWP	Paris Agreement Work Programme
RE	Renewable Energy
RES	Renewable Energy Sources
R&I	Research and Innovation
RLDC	Regionally and Locally Determined Contribution
SDG	Sustainable Development Goal
SIDS	Small Island Developing States
UNFCCC	United Nations Framework Convention on Climate Change

Glossary[1]

Absolute emissions reduction targets – A target adopted, usually by a national government, to reduce total (i.e. absolute) GHG emissions over a period of time, as compared to a base year. This is distinct from intensity-based GHG reduction targets, which seek to reduce the GHG emissions associated with an activity or other unit (e.g. GHG emissions per unit of GDP).

Carbon neutrality - This refers to achieving net zero CO_2 emissions where anthropogenic carbon dioxide emissions are balanced by CO_2 removals.

Climate neutrality – According to the IPCC, this concept refers to a state in which human activities cause no net effect on the climate system. To achieve climate neutrality residual emissions need to be balanced by emission removals while any regional or local biogeophysical effects of human activities are addressed. In this study, the term 'climate neutrality' refers to achieving net zero GHG emissions following the meaning used in the European Commission's 2050 Long Term Strategy (COM(2018) 773). Achieving **net zero emissions** refers to balancing anthropogenic emissions of any or all GHGs by removals of GHGs.

Decarbonisation - The process by which countries, individuals or other entities aim to achieve reductions of the carbon emissions of a given activity.

Demand-side measures - Policies and programmes for influencing the demand for goods and/or services. In the energy sector, such measures aim at reducing the demand for electricity and other forms of energy.

Green infrastructure - The interconnected set of natural and constructed ecological systems, green spaces and other landscape features. It includes planted and indigenous trees, wetlands, parks, green open spaces and original grassland and woodlands, as well as possible building and street-level design interventions that incorporate vegetation.

Greenhous gases (GHGs) - Natural and anthropogenic gases that cause the greenhouse effect. The Kyoto Protocol deals with carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), sulphur hexafluoride (SF_6), hydrofluorocarbons

[1] Based on *'Annex I: Glossary'* in IPCC, 2018, Global Warming of 1.5°C: An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty; and IASS, 2015, Long-term climate goals: Decarbonisation, carbon neutrality, and climate neutrality.

(HFCs), perfluorocarbons (PFCs) and, since 2012, nitrogen trifluoride (NF_3). Other GHGs are dealt with under the Montreal Protocol.

Negative emissions - Removal of GHGs from the atmosphere by deliberate human activities i.e. in addition to the removal that would occur via natural processes.

Stranded Assets - Assets exposed to devaluations or conversion to 'liabilities' because of unanticipated changes in their initially expected revenues due to innovations and/or evolutions of the business context.

Supply-side measures - Policies and programmes for influencing how a certain demand for goods and/or services is met. In the energy sector, such measures aim at reducing the GHG emissions per unit of energy produced.

Executive Summary

In November 2018, the European Commission published a 2050 Long Term Strategy (LTS) that aims to outline long term decarbonisation objectives for the EU and explore the possibilities for reaching the Paris Agreement goals and climate neutrality by 2050. In response to the LTS, the European Committee of the Regions (CoR) is preparing an Opinion and this report aims to support the CoR by providing insights concerning the LTS scenarios and their impacts, the role of local and regional authorities (LRAs) in the LTS, the potential role of the National Energy and Climate Plans (NECPs) in the implementation of the LTS and the consistency of the LTS with the implementation of the Paris Agreement.

The LTS and the In-Depth Analysis that supported it outline eight scenarios for decarbonisation and, in the two most ambitious cases, for reaching climate neutrality by 2050. The scenarios are based on combinations of technological options in the sectors contributing the most to CO_2 emissions and behavioural changes and lifestyle choices that can further reduce emissions of greenhouse gases (GHGs). The results of the scenarios highlight the need to pursue a combination of options and technologies for reducing emissions across sectors if climate neutrality is to be achieved. The In-Depth Analysis of the LTS also examined some of the impacts that the scenarios might have on the EU economy. Most significantly, the different scenarios will require significant investments and are likely to reduce or transform different economic sectors with possible implications for employment. Even though the In-Depth Analysis does not study the environmental impacts of the scenarios in detail, they are likely to have a positive influence on air quality and a mixed impact on nature, biodiversity and resource use.

The LTS formally recognises the role of LRAs in influencing consumer choices and lifestyles. Nevertheless, LRAs will have an important role to play in setting up the enabling framework required to support all scenarios and the objective of climate neutrality and their actions will be key elements of the 'building blocks' for action described in the LTS. In particular, LRAs can contribute to: the improvement of energy efficiency; the deployment of renewable energy and electrification; the development of clean mobility networks; supporting the transition of European industries; the expansion of the bio-economy; and the development of the infrastructure required for decarbonisation and climate neutral alternatives. Furthermore, LRAs will have the key roles of managing benefits and risks at the local level and engaging local communities in the design and implementation of policies for climate action.

With the new Governance Regulation (Regulation 2018/1999) Member States are expected to prepare comprehensive NECPs that outline the measures they will use to support the implementation of the Energy Union objectives, including decarbonisation and GHG emissions reduction. The structure of the NECPs requires Member States to provide information on a variety of issues that are relevant for the enabling conditions required to implement the LTS. However, they are less focused on demand-side measures and actions for influencing lifestyle choices and it would be up to the Member States to make links to relevant circular economy or other demand-side measures in their NECPs. Moreover, the NECPs are national level documents and measures taken by LRAs are not explicitly covered. Nonetheless, a multi-level climate and energy dialogue has been launched with the purpose of linking different levels of governance and involving LRAs in the development of the NECPs.

The NECPs and their reporting cycle are likely to support the EU's reporting requirements under the Paris Agreement. Under the recently agreed framework for implementation or the so-called 'Rulebook' Parties to the Agreement will have to regularly submit Nationally Determined Contributions (NDCs) outlining their ambitions and efforts to achieved the Paris objectives. In addition, they will report on the progress made every two years. The agreement of this overall transparency framework is considered a major step forward in the implementation of the Paris Agreement, even though some specific aspects still need to be agreed and defined. One such aspect is the role of LRAs in the process of international climate negotiations. While the role remains consultative, a platform for formal consultation in the development of the NDCs was introduced within the Talanoa Dialogues and might provide more opportunities for contribution in the future.

The ambitious vision the EU has put forward for reaching the climate goals of the Paris Agreement in the LTS is an important step. However, the success of this ambitious vision will depend on having a coherent EU policy framework at all levels of governance that can enable and support the transition to climate neutrality while its impacts are carefully managed. Therefore:

- EU and national policy-makers should:
    - Ensure the various impacts of the LTS are well understood;
    - Put in place a policy framework that can implement the LTS;
    - Involve all levels of governance in the decision-making process.

- Local and regional policy-makers should:

    - Support EU and national policies for implementation of the LTS;
    - Explore various financing options to meet the investment needs of the LTS;
    - Manage risks and opportunities at the local level;
    - Support participatory decision-making and engagement with local stakeholders.

Introduction

The historic Paris Agreement[2], signed during the 21st Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) in 2015, aims to strengthen the global response to climate change after 2020 by keeping global temperature rise 'well below 2°C' and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels. The implementation of the Agreement will be supported through the Parties' Nationally Determined Contributions (NDCs) or 'pledges', which embody the efforts made by each country to reduce their emissions and adapt to the impacts of climate change. The NDCs will also be the main tool for measuring progress towards the achievement of the Paris' goals.

While this represents a significant step towards global efforts to mitigate climate change, the Intergovernmental Panel on Climate Change (IPCC) concluded that current NDCs for 2030 are not sufficient to limit global warming to 1.5°C by 2050. In its 2018 Special Report[3] (hereafter 'IPCC 1.5 Report') the Panel found that current NDCs will likely result in over 3°C increase of the global temperature by the end of the 21st century and that the world has only 12 years to run over the carbon budget available on a 1.5°C pathway. Achieving the current pledges means that the temperature rise would exceed 1.5°C at least for a period of time and returning to that level would require removing CO_2 from the atmosphere.

The EU is already working on developing the policies needed to implement its NDC and putting in place its 2030 climate and energy framework. In addition, the European Commission published a 2050 Long Term Strategy (LTS)[4] that aims to outline long term decarbonisation objectives for the EU and explore the possibilities for reaching the Paris Agreement goals and climate neutrality by 2050.

Ongoing work to update relevant EU policies (including the ETS, the Effort Sharing legislation concerning emissions from non-ETS sectors, the Renewable Energy Directive and the Energy Efficiency Directive) aims to ensure achievement of the EU's 2030 climate and energy targets[5]:

[2] UNFCCC, 2016, Decision 1/CP.21: Adoption of the Paris Agreement.
[3] IPCC, 2018, Global Warming of 1.5°C: An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.
[4] European Commission, 2018, A Clean Planet for all: A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy, COM(2018) 773.
[5] Ibid. p.5.

- 40% reduction of greenhouse gas (GHG) emissions (compared to 1990 levels), which translates to a 43% GHG emissions reduction in sectors covered by the EU Emissions Trading System (ETS) and a 30% GHG emissions reduction in non-ETS sectors (both compared to 2005 levels);
- 32% share of renewable energy (RE) in final energy consumption;
- 32.5% improvement of energy efficiency (EE).

However, without further action these targets would result in a fall of EU's GHG emissions by around 45% by 2030 and only 60% by 2050, which falls short of the ambitions outlined by the Paris Agreement[6]. Therefore, the LTS highlights the need for coordinated action across sectors, policies and governance levels. The new Governance Regulation (GR)[7] aims to support this by asking Member States to prepare integrated National Energy and Climate Plans (NECPs) that outline their targets and policies for decarbonisation of the energy sector alongside other actions supporting the Energy Union objectives.

The in-depth analysis accompanying the LTS[8] (hereafter 'LTS In-depth Analysis') stresses also the importance of local and regional authorities (LRAs) in economic, spatial and environmental planning at the local level, which will be critical for a low-carbon transition. Consequently, LRAs are expected to be an integral part for the success of the long-term decarbonisation scenarios of the LTS. In response to the LTS, the European Committee of the Regions (CoR) is preparing an Opinion and this report aims to support the CoR by providing insights concerning:

- The LTS scenarios and their impacts;
- The role of LRAs in the LTS and its scenarios;
- The potential of the NECPs to support the implementation of the LTS;
- The alignment between the LTS and the implementation of the Paris Agreement.

The following parts of the report provide analysis and findings for each of these aspects (Parts 1-4), while Part 5 outlines relevant recommendations.

[6] Ibid. p.5.
[7] Regulation (EU) 2018/1999 […] on the Governance of the Energy Union and Climate Action.
[8] European Commission, 2018, In-Depth Analysis in Support of the Commission Communication COM(2018) 773: A Clean Planet for all, A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy. Hereafter 'LTS In-depth Analysis'.

1. Part 1: The EU Long Term Strategy scenarios and their impacts

The LTS is based on several pathways for decarbonisation and transition to climate neutrality with different levels of ambition and technological options, which in turn would have varying impacts and possible implications for governance. This Part provides an overview of the LTS scenarios, their main differences and impacts based on the LTS In-depth Analysis. It also explores the consistency of these scenarios with the IPCC 1.5 Report.

1.1 Overview of the LTS scenarios and their main assumptions

The analysis behind the LTS[9] considered eight different pathways or scenarios that can ensure the EU's contribution to the Paris Agreement and the objectives of keeping the global temperature change below 2°C or 1.5°C by 2050 based on literature review and modelling[10]. The impacts of the scenarios are compared to a baseline that reflects the current EU GHG emissions reduction trajectory based on the implementation of agreed or proposed policies, including the various legislative proposals of the Clean Energy package[11]. The baseline assumes successful implementation of the 2030 climate and energy targets, the measures for nearly zero emission new buildings under the new Energy Performance of Buildings Directive[12] and a steady decrease of the ETS cap with 2.2% each year as expected under the revised legislation[13]. Therefore, the use of renewable energy sources (RES), energy efficiency (EE) and electrification grow under the baseline and all decarbonisation and climate neutrality scenarios. However, the baseline does not reflect specific Member State policies adopted after 2015 or new policies developed in the context of the NECPs. The implementation of other EU policies, for instance concerning waste and fluorinated gases (F-gases), is also assumed to be successful.

Building upon the baseline and additional assumptions and enabling conditions, the eight scenarios are outlined in section 1.1.3 below.

[9] LTS In-depth Analysis, Sections 3 and 4.
[10] The emissions analysis used primarily the PRIMES-GAINS-GLOBIOM model, which covers all sectors and GHGs; the FORECAST model was used to complement the analysis for the industry. The macro-economic analysis was based on the GEM-E3, E3ME and QUEST models.
[11] DG ENER, Commission proposes new rules for consumer centred clean energy transition website.
[12] Directive (EU) 2018/844.
[13] Directive (EU) 2018/410.

1.1.1 Assumptions

The LTS pathways are based on several common assumptions:

- Higher energy efficiency after 2030 and moderate circular economy;
- Deployment of sustainable, advanced biofuels but Bioenergy with Carbon Capture and Storage (BECCS)[14] only after 2050 in the 2°C scenarios;
- Digitalisation and market coordination for infrastructure deployment;
- Significant 'learning by doing' for low-carbon technologies[15];
- Significant improvements in the efficiency of the transport system.

1.1.2 Enabling conditions

The success of the options and drivers for decarbonisation and climate neutrality proposed in the LTS scenarios will depend on a variety of enabling conditions. Even though these can differ per sector, there is a number of 'general' enabling conditions that can be drawn from the LTS In-depth Analysis:

- **Infrastructure development** to accommodate changes in all sectors such as integration of more RES in the energy system, development of charging infrastructure for electric vehicles, creation of new types of industrial facilities and management of decommissioned energy or industrial assets;

- **Research and innovation** (R&I) in novel technologies for all sectors, including alternative energy carriers to replace fossil fuels in transport and industry, RES, Carbon Capture and Storage/ Utilisation (CCS or CCU) technologies, low-carbon basic material products and options for reducing methane emissions from agriculture;

- **Digitalisation** to help manage energy demand (e.g. through smart grids and smart buildings) and transport needs, as well as to develop precision farming solutions;

- **Demand-side actions**, including eco labels, to help raise awareness and shift consumer and business choices as well as industrial design to more energy and resource efficient products;

[14] BECCS refers to the application of Carbon Capture and Storage (CCS) technology to a facility producing energy from biomass.
[15] The concept of 'learning by doing' often refers to economies of scale, cost reductions and/or innovations that are realised through the wider deployment of a new technology or process.

- **Full implementation of existing legislation** to ensure timely progress before all enabling conditions are met;

- **A policy framework** and **financing options** to ensure the enabling conditions are supported.

1.1.3 The LTS scenarios

The different LTS scenarios cover various sectoral options for reducing GHG emissions to differing extents by 2050, including demand-side, technological and negative emissions alternatives, that go beyond the potential in the baseline. While the CO_2 emissions fall in the long-run under all scenarios, non-CO_2 emissions as a share of all GHGs, particularly methane emission, decline up to 2030 but then increase by 2050 in the baseline. Non-CO_2 emissions, particularly in agriculture, will be more difficult to reduce towards zero emissions than those from CO_2 sectors. Consequently, a certain amount of GHG continues to be released in all cases, i.e. absolute zero GHG emissions cannot realistically be achieved. Thus, achieving net zero or net negative emissions by mid-century in the most ambitious scenarios will require not only a reduction of GHG emissions but also CO_2 removals through both natural (carbon sinks) and technological solutions (carbon dioxide removal) to compensate for emissions that cannot be avoided (including, for example, non-CO_2 emissions from agriculture).

The alternatives considered for driving down GHG emissions in the different pathways include enhanced implementation of well-established low-carbon options such as RE, EE and electrification of transport as well as options that are technologically feasible but not yet widely used such as replacement of fossil fuels with low-carbon energy carrier alternatives in different industrial processes and transport (electrification, use of hydrogen (H_2) or synthetic fuels produced from decarbonised electricity (e-fuels)). Electrification is expected to be easier for industry and light-duty vehicles (LDVs), while heavy-duty vehicles (HDVs) are more likely to switch to low-carbon energy carriers. Last but not least, behavioural changes in consumer and societal choices are also considered, including lifestyle and dietary changes (for further details about the emission reduction alternatives considered for each sector see Annex 2).

The options considered for ensuring net zero or negative emissions through carbon dioxide removal in the most ambitious scenarios include land use, land use change and forestry (LULUCF) and deployment of CCS and CCU technologies. The LULUCF sector covers both CO_2 emissions and CO_2 removals through land use activities related to forest, cropland, grassland, settlements, wetland and other land management or changes in land use. In the

EU, the LULUCF sector is currently a net carbon sink as it sequesters more carbon than it emits each year and as this trend is expected to continue, the sector can help offset some GHG emissions in the long-run. CCS and CCU technologies are assumed to develop further from the current technology readiness levels and accelerate particularly after 2040. Hence, they are an important part of scenarios that rely heavily on electricity generation or negative emissions and are considered a key complementary measure for reducing industrial emissions[16].

More specifically, five of the scenarios reflect prioritised deployment of one 'main' decarbonisation alternative - electrification, use of H_2 or e-fuels, EE or resource efficiency improvements – without accounting for carbon sinks. All these scenarios can limit global temperature increase 'well below 2^{o}C', which translates to an 80% reduction of the EU's GHG emissions by 2050 (compared to 1990 levels). The sixth scenario covers a combination of options and technologies from the first five pathways and can thus achieve higher GHG emissions reduction (nearly 90% compared to 1990 levels with carbon sinks accounted for). The last two scenarios are the most ambitious and consider the possibilities to reach the 1.5^{o}C objective or 100% reduction of the EU's GHG emissions by 2050 (compared to 1990 levels with carbon sinks accounted for) and climate neutrality. Compared to the other pathways, the most ambitious scenarios rely on a combination of the five main decarbonisation options, negative emissions/ carbon sinks through the deployment of BECCS or significant changes in lifestyle and consumer choices. This highlights the need to combine various low-carbon options and avoid overreliance on only one option, if climate neutrality is pursued in the long-term. The main differences between the LTS scenarios are summarised in Table 1.

[16] Simon, F. 2019, 'It's complicated': EU offers political backing but no funding for CCS.

Table 1: Overview of the LTS scenarios

Scenario		Ambition by 2050	Drivers	Energy	Industry	Buildings	Transport
0	Baseline	64% reduction of GHG emissions (incl. LULUCF/ carbon sinks)	Existing technological options and policy ambitions	Implementation of the existing and proposed policies, including realisation of the 2030 climate and energy targets and a reduction of the ETS cap with 2.2% per year			
1	**ELEC** Electrification	80% reduction of GHG emissions (excl. LULUCF/ carbon sinks)/ 'well below 2°C' ambition	Electrification in all sectors	Power is nearly decarbonised by 2050 with system optimisation that facilitates RES penetration (demand-side response, storage, interconnections, prosumers). Nuclear still plays a role. CCS faces limitations.	Electrification of processes	Increased deployment of heat pumps	Faster electrification for all modes
2	**H2** Hydrogen		Hydrogen in industry, transport, buildings and gas distribution network		Use of H_2	Deployment of H_2 for heating	Deployment of H_2 for HDVs and some LDVs
3	**P2X** Power-to-X		E-fuels in industry, transport, buildings and gas distribution network		Use of e-gas	Deployment of e-gas for heating	Deployment of e-fuels for all modes
4	**EE** Energy efficiency		Deep energy efficiency in all sectors		Energy efficiency decreases energy demand	Increased renovation rates	Increased modal shift
5	**CIRC** Circular economy		Increased resource & material efficiency		Higher recycling, material substitution and circular measures	Sustainable buildings	Mobility as a service
6	**COMBO** Combination	90% reduction of GHG emissions (incl. LULUCF/ carbon sinks)	Combination of scenarios 1-5		Combination of most cost-efficient options from scenarios 1-5 with targeted application		
7	**1.5 TECH** 1.5°C Technical	100% reduction of GHG emissions (incl. LULUCF/ carbon sinks)/ 1.5°C ambition	Scenario 6 with more CCS, BECCS (limited enhancement of natural sink)		Like scenario 6 but enhanced		
8	**1.5 LIFE** 1.5°C Sustainable Lifestyles		Scenarios 5 & 6 with lifestyle changes, dietary changes & enhanced natural sink		Like scenarios 5 & 6 but enhanced		Like scenarios 5 & 6 but enhanced with alternatives to air travel

Source: Own analysis based on European Commission, 2018, In-Depth Analysis in Support of the Commission Communication COM(2018) 773: A Clean Planet for all, A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy, Sections 3 and 4, and Table 1 on p. 56.

The different LTS pathways for decarbonisation and climate neutrality are built upon possible measures and options primarily in CO_2 emitting sectors – energy, transport, buildings and industry. Therefore, the key outcomes of the scenarios, some of which are shared across different scenarios (summarised in Box 1), concern those sectors. Depending on the specific technological or other mitigation options driving each scenario and the key sectoral outcomes, the impacts of the LTS scenarios will vary. These impacts are explored in more detail in the following sections.

Box 1: Key sectoral outcomes in the LTS scenarios[17]

In all scenarios:

- Both CO_2 and non-CO_2 (mainly methane (CH_4) and F-gases) emissions decrease by 2050.
- Energy demand decreases, which reduces energy consumption and the need for energy generation, mainly in the buildings sector. The highest impact is observed in the EE, CIRC and 1.5 LIFE scenarios as these include wide-spread EE and resource efficiency improvements in all sectors combined with demand-side measures.
- Electricity (which will be largely supplied by RES) is the dominant energy source in all scenarios; its share is highest under the ELEC scenario.
- The share of RES increases significantly with the leading technology being wind (mainly offshore wind). Biomass demand grows and even doubles by 2050 in some scenarios.
- Nuclear energy remains a part of the energy mix and grows slightly compared to the baseline as a result of increased demand for electricity[18].
- There is a modal shift in transport towards more rail (for passengers) and inland navigation (for freight). The strongest effects are observed in the EE, CIRC and 1.5 LIFE scenarios.
- Conventional fossil fuel-powered vehicles are replaced by hybrids or electrically powered vehicles (for LDVs) or alternative low-carbon fuels (for HDVs), mostly under the EE, ELEC, CIRC and the 1.5 options.
- Solid fuels nearly disappear from the energy system being replaced by electricity, H_2 and e-fuels and those that remain in the system are mainly for non-energy uses i.e. raw materials in the industry (e.g. plastics).
- Energy consumption in industry also reduces, mostly under the 1.5 LIFE (mainly through consumer choices and circular economy that result in less demand for new goods), EE, CIRC and 1.5 TECH scenarios.
- Removing CO_2 from the atmosphere (either by natural sink or engineering technologies such as CCS/CCU) are necessary to achieve net zero emissions in the most ambitious scenarios. Natural sinks can be increased by ecosystem restoration, afforestation, reforestation, improved forest and soil management, while CCS/CCU infrastructure needs to be developed.

[17] Summary based on LTS In-depth Analysis, Sections 3 and 4.

[18] The LTS and its In-Depth Analysis do not aim to prescribe specific technologies as the main decarbonisation options. In the case of nuclear energy, the LTS In-depth Analysis stresses that decisions about using nuclear energy are a competence of the Member States rather than the EU. The LTS In-depth Analysis points out that there is a variety of situations across the EU with some Member States already having nuclear capacities, others planning to install some or having announced they will phase out nuclear energy. The assumptions behind the LTS scenarios are based on existing literature and international trends that indicate nuclear energy will remain part of the mix until 2050 and, therefore, consider the existing installed capacities, their lifetimes and confirmed plans for new capacities in the Member States.

1.2 Environmental impacts and risks of the LTS scenarios

The impacts of the LTS pathways will depend on the specific technological and other emission reduction options selected. The LTS In-depth Analysis does not focus on the broader environmental impacts of the scenarios beyond their effect on reducing GHG emissions and benefits for air quality. Therefore, the following sub-sections consider the key sectoral outcomes outlined in the LTS In-depth Analysis (see Box 1) and draw conclusions about the potential impacts these outcomes may have on key environmental areas based on additional analysis (for a summary see Table 4 in Annex 2).

1.2.1 Air quality

Air quality is affected by the concentration of pollutants emitted from anthropogenic or natural sources. Key air pollutants include particulate matter (PM), sulphur oxides (SO_x), nitrogen oxides (NO_x), ozone (O_3), benzene (C_6H_6), benzo[a]pyrene (BaP), ammonia (NH_3) and methane (CH_4). Many of the sources of GHG emissions are also sources of air pollutant emissions. Combustion processes from energy production or transport are primary sources of NO_x, SO_x, PM, C_6H_6 and BaP emissions, and contribute to concentrations of secondary O_3 through NO_x emissions. Fuel combustion for domestic heating or power generations is a key source of PM emissions. Agriculture and waste management contribute to methane emissions while industrial activity is a source for emissions of toxic metals. Agriculture is also a key source of ammonia emissions.

Even though emissions of the main air pollutants in the EU decreased over the period 2000-2016, they remain a concern as concentrations in many EU urban areas reach levels that can have significant impacts on human and environmental health. In particular, air pollution is a major cause of premature deaths and heart and lung diseases resulting in approximately 400,000 premature deaths per year. It can also affect biodiversity and disrupt the ecosystem services provided though eutrophication from increased levels of nutrient nitrogen or acidification of soils from NO_x and SO_x. In addition, O_3 can damage crops and biomass while some gases released from incomplete fossil fuel combustion contribute to global warming (e.g. the black carbon component of PM)[19].

The fall of GHG emissions across all LTS scenarios implies significant positive impacts on air quality might be realised under all decarbonisation and climate neutrality pathways. The fall of CO_2 emissions is due to a decrease of energy

[19] EEA, 2018, Air quality in Europe – 2018 report, EEA Report No 12/2018.

demand in combination with more efficient heating and cooling, energy production and consumption in all sectors. The highest impact is observed in the EE, CIRC and 1.5 LIFE scenarios, as these options rely on higher levels of EE, resource efficiency and behavioural changes that favour energy efficient appliances and resource conservation. Another source of lower CO_2 emissions is the transport sector where conventional fossil fuel-powered vehicles are replaced by hybrids, electrically powered vehicles (for LDVs) and alternative fuels (for HDVs), particularly under the EE, ELEC, CIRC, 1.5 TECH and 1.5 LIFE scenarios[20]. These changes imply a lower demand for fossil fuels in energy generation and transport and thus avoided emissions of NO_x, SO_x, PM, C_6H_6 and BaP from combustion processes that can improve air quality in general.

Furthermore, an important effect in the CIRC and 1.5 LIFE scenarios is an expected decrease in demand for goods as well as a development of more efficient production processes[21]. This can potentially result in fewer emissions from industrial processes of e.g. NO_x, SO_x from combustion activities or toxic metals from other industrial processes. In addition, the LTS scenarios are expected to result in a 40% decrease in deaths from PM and ozone exposure[22].

Finally, there are strong links between climate change and air quality. Climate change can drive air pollution in a number of ways. Climate change can impact air quality by influencing atmospheric chemistry through temperature increases, disrupting deposition and ventilation rates through changes in wind and rainfall patterns, and increasing emissions from wildfires and dust storms[23]. Higher temperatures are believed to worsen surface ozone concentrations, in what is referred to as the 'climate penalty' by the IPCC[24]. Therefore, if EU efforts under the LTS to limit climate change are successful – which is to a large extent dependent on international cooperation – there are likely to be benefits for air quality.

1.2.2 Nature and biodiversity

Natural capital, biodiversity and the ecosystem services and the benefits they provide can be affected by various anthropogenic activities. In particular, ecosystem services and biodiversity can be jeopardised by the degradation or fragmentation of land, desertification, soil degradation, erosion, contamination

[20] LTS In-depth Analysis, Section 4.
[21] Ibid.
[22] Ibid.
[23] Jacob, D., J., and Winner, D., A., 'Effect of climate change on air quality', in *Atmospheric Environment* 43 (2009) 51-63, 2009.
[24] IPCC, 2013, Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, p.684.

or sealing, eutrophication or poor water quality. These factors result primarily from urbanisation, infrastructure development, intensification of agricultural production and industrial activities. More specifically, urbanisation and infrastructure development can lead to land use changes, fragmentation or loss of habitats. Agriculture contributes to the release of nutrient nitrogen and in combination NO_x emissions in the air can lead to eutrophication, while intensive practices can result in soil degradation, compaction or sealing. Industrial activities, on the other hand, can emit pollutants and toxic metals into terrestrial and aquatic ecosystems compromising them. Last but not least, nature and biodiversity will be impacted by the changing climate and extreme weather events this entails. Despite improvements since 2000 the EU is not meeting its targets for halting biodiversity loss[25].

The LTS scenarios are built around various actions and technology developments that are likely to have mixed impacts on nature and biodiversity. Firstly, a decrease of GHG emissions in all scenarios and a lower limit for the expected temperature change might help mitigate the negative impacts of a changing climate on biodiversity and ecosystems. Moreover, in the energy sector the share of RES is expected to grow in all scenarios[26]. This overall increase of RE use can have a positive impact on nature and biodiversity through the replacement of fossil fuels and the need for their extraction, transport and combustion, while associated improvements of air quality (see the previous section), reduced eutrophication and acidification can further enhance those impacts.

However, depending on the type of RES used, the impacts on biodiversity may vary. The risk of RES and energy infrastructure development impacting nature and biodiversity have already been considered by the European Commission and covered by several guidance documents that aim to ensure compatibility between the development of RES and energy infrastructure and nature conservation and biodiversity protection objectives. So far specific guidelines in relation to the EU nature legislation have been issued for wind energy[27], hydropower[28] and energy transmission infrastructure[29]. Given the great significance of RES technologies and the need for infrastructure development in all LTS scenarios, following these guidelines will be critical for mitigating any risks to nature and biodiversity.

[25] EEA, 2016, The European Environment – state and outlook 2015 – synthesis report, 3. Protecting, conserving and enhancing natural capital.
[26] LTS In-depth Analysis, Section 4.
[27] European Commission, 2011, Wind energy developments and Natura 2000.
[28] European Commission, 2018, Guidance document on the requirements for hydropower in relation to EU Nature legislation.
[29] European Commission, 2018, Guidance on Energy Transmission Infrastructure and EU nature legislation.

Particularly important is the expected prominence of biomass as an energy source (notably in the 1.5 TECH scenario that relies on the BECCS technology) and a carbon sink. The growing demand for biomass is expected to be met by two main sources according to the LTS In-depth Analysis: wood and lignocellulosic crops[30]. Sourcing additional wood can put pressure on forest ecosystems while growing more crops for bioenergy may result in land use changes that impact ecosystems and biodiversity. Sustainable forest management, afforestation and sustainable agricultural practices will be key for mitigating any negative impacts and balancing the effects on ecosystems. Special attention should be paid also to the risk of indirect land use changes and impacts on biodiversity in third countries through the increased demand for biomass. In addition, nuclear energy remains a part of the energy mix in all scenarios, increasing slightly compared to the baseline, as current or recently installed capacities have long lifetimes and can help balance variable RES. However, this implies that risks to human health and nature from nuclear waste exist under all LTS scenarios.

In the transport sector a modal shift to rail and inland navigation are expected in all scenarios and especially 1.5 LIFE[31]. This shift may positively impact nature and biodiversity through improved air quality as rail transport is electrified while navigation is expected to rely on non-fossil fuels (see the previous section). However, the shift might also necessitate the development of new rail and inland navigation infrastructure, which may pose additional pressures on terrestrial and aquatic ecosystems. New infrastructure, with its associated pressures on nature and biodiversity, might also be required to accommodate changing industrial processes and the development of CCS/CCU facilities in the scenarios that rely on negative emissions. It remains unclear how novel industrial processes that may reduce GHG emissions and make production more efficient might affect the release of other pollutants (e.g. toxic metals) into water and soil and the associated effects this has on ecosystems.

1.2.3 Resource use

Economic activity and socio-economic progress rely on finite natural resources and global competition for them is growing. Moreover, there are competing needs for some resources such as water or biomass from various sectors that can result in additional pressures. Therefore, ensuring resource efficiency and an overall lower quantity of resources used by the economy is important for decreasing the pressure on resources and ecosystems. Even though there are recent improvements in resource productivity in the EU, consumption patterns

[30] LTS In-depth Analysis, Section 4.
[31] LTS In-depth Analysis, Section 4.

remain resource intensive. Furthermore, water stress and water scarcity are significant concerns in parts of the EU and are likely to become more acute in a changing climate[32].

The baseline and the LTS scenarios are built upon the assumption that current EU resource efficiency and circular economy policies are implemented and enhanced by consumer choices. The most significant positive impacts on resource use are expected under EE, CIRC and 1.5 LIFE pathways as they rely heavily on improved energy and resource efficiency in all sectors as well as consumer awareness and choices that favour rational resource use and appliances that save energy and water[33].

Nevertheless, some mixed or potentially negative impacts on resources might arise from other expected outcomes of the scenarios. The expected rise of RES as a key energy source might put additional pressure on resources depending on the technology employed. Some technologies would require additional raw materials to produce specific parts (e.g. wind turbines, solar panels) or batteries, while the production of biomass for energy would increase the demand for water in agriculture. New hydropower capacity and the production of nuclear energy might put additional pressure on freshwater resources as well.

Another resource that might face growing demand from competing sectors in the different scenarios is forest biomass. As noted earlier it is expected to serve both the increasing demand for biomass in energy supply and the need to sequester some of the CO_2 emissions if net zero emissions are to be achieved. At the same time wood remains an important raw material in many sectors.

1.2.4 Adaptation

The LTS and its scenarios are focused on mitigation and consider adaptation to the impacts of climate change to a limited extent. Specific adaptation considerations are not reported per scenario but general information about the need to undertake adaptive actions and improve resilience is highlighted. The LTS In-depth Analysis stresses the important co-benefits and trade-offs that exist between mitigation and adaptation activities and mentions some 'no-regret' options that can provide key co-benefits for adaptation, for instance ecosystem restoration and conservation and green infrastructure[34].

[32] EEA, 2016, The European Environment – state and outlook 2015 – synthesis report, 4. Resource efficiency and the low-carbon economy.
[33] LTS In-depth Analysis, Section 4.
[34] LTS In-depth Analysis, Section 5.9.

1.3 Socio-economic impacts and risks of the LTS scenarios

The LTS In-depth Analysis [35] provides an overview of the economic effects on several key sectors as well as some broader social impacts, these findings are summarised in the following sub-sections.

1.3.1 Economic impacts

At macro-economic level an important consideration is to what extent economic growth can be decoupled from GHG emissions and intensive resource use. The modelling for the LTS pathways suggests that a trend of decoupling the Gross Domestic Product (GDP) from GHG emissions started in 1990s and is expected to continue in all scenarios ensuring that economic growth in the EU continues while the goal of net zero emissions is pursued. Moreover, net zero pathways are expected to have a positive impact on GDP increasing growth compared to the baseline when combined with a coherent enabling framework[36].

Another key impact is an increasing need for investment and financial resources to fund the changes that need to take place under the different scenarios, particularly the development of the energy infrastructure needed for the various decarbonisation and climate neutrality options, the implementation of demand-side measures (e.g. EE) and the replacement of the vehicle fleet to accommodate new fuels. As the baseline assumes implementation of current policies, the investment needs until 2030 are very close across the LTS pathways and the baseline. However, the necessary investments and associated costs differ more significantly beyond 2030 depending both on the ambition of the scenarios and the capital intensity of the decarbonisation options considered. Overall, the 1.5°C pathways require on average EUR 1.42 trillion of annual investments in the period 2031-2050 or 6.7% more than the average EUR 1.33 trillion necessary per year in 2°C scenarios. In both cases, this is more than the investments that would be necessary under the baseline scenario (see Table 2).

[35] LTS In-depth Analysis, Section 4.10.
[36] European Commission, 2018, A Clean Planet for all: A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy, COM(2018) 773, p.19.

Table 2: Average annual investment by scenario for the period 2031-2050 (billion EUR 2013)

Sector	2021-2030 (all)	Baseline	EE	CIRC	ELEC	H2	P2X	COMBO	1.5 TECH	1.5 LIFE
Power grid	59.2	71.3	80.7	91.0	110.3	91.1	95.3	99.4	102.8	90.3
Power plants	53.9	40.2	50.5	60.3	76.8	86.6	107.9	93.6	120.3	93.9
Boilers	1.7	1.3	1.1	1.8	1.9	1.0	0.6	0.7	0.8	0.6
New carriers	0.1	0.3	0.9	0.9	1.0	5.5	28.9	16.2	21.9	16.5
Total: Energy – supply side	**115**	**113**	**133**	**154**	**190**	**184**	**233**	**210**	**246**	**201**
Industry	18.1	11.1	35.6	13.2	13.6	13.2	13.8	26.3	21.1	22.3
Residential	198.9	199.4	235.1	211.6	214.4	198.9	198.1	218.3	225.9	227.7
Tertiary	64.3	53.7	63.8	60.3	57.0	58.0	59.5	67.1	76	67.8
Total: Energy – demand side	**281**	**264**	**335**	**285**	**285**	**270**	**271**	**312**	**330**	**318**
Transport	**685**	**813**	**857**	**837**	**881**	**907**	**843**	**881**	**904**	**847**
TOTAL	**1081**	**1190**	**1325**	**1276**	**1356**	**1361**	**1347**	**1402**	**1480**	**1366**

Source: European Commission, 2018, In-Depth Analysis in Support of the Commission Communication COM(2018) 773: A Clean Planet for all, A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy, Section 4, Table 10, p. 202.

More specifically, in the three most ambitious (and thus most 'costly') scenarios the largest investments will be required in the 1.5 TECH alternative and the least in the 1.5 LIFE option, which might be explained by the more significant role capital intensive technologies such as BECCS and CCS/CCU have in the 1.5 TECH pathway. In the 2°C scenarios, on the other hand, the largest investments will be necessary in the H_2 alternative as the replacement of conventional fuels in the different sectors requires significant capital. The least 'costly' scenarios will be CIRC and EE. These trends show the potential of pathways relying on more energy and resource efficiency as well as lifestyle changes to reduce the amount of additional investments needed for a transition to climate neutrality. Compared to the investments required for emissions reduction in the baseline, the 1.5°C pathways will require additional annual investments of EUR 233 billion on average, while the 2°C scenarios will need on average EUR 143 billion more per year (for details see Table 5 in Annex 2).

Similar trends are observed for the energy system costs and electricity prices for final users, which are identical to the baseline until 2030 but diverge by scenario afterwards, with lower costs/prices expected for the scenarios that rely on demand-side measures and higher costs/prices for those that rely on new energy carriers or technological solutions (see Figure 3 and Figure 4 in Annex 2). Across the different industrial sectors changes will be required both in the amounts and types of investments needed in all LTS scenarios. While investments in some sectors, notably fossil fuels, are expected to be lower compared to the baseline, investments in other sectors, especially electricity

supply, will increase (see Table 6 in Annex 2). Even though the need for divestment and phase out of fossil fuel is mentioned together with the importance of avoiding costs (e.g. in industrial sectors or energy systems), the LTS and its In-Depth Analysis do not provide details about the size of these divestments or avoided costs. The analysis behind the LTS scenarios specifies also that the current Best Available Techniques (BATs) for industry are not sufficient to deliver the GHG emission reductions required in the scenarios, however, it does not elaborate further.

Nonetheless, the analysis outlines the main areas, in which further R&I is necessary to ensure the technological solutions required to realise the LTS scenarios are developed and commercialised, highlighting the need to develop a portfolio of emission reduction alternatives and avoid technological lock-in or overreliance on a single technology. Those areas include climate science, low-carbon technologies (e.g. RE, electrification and batteries, H_2, synthetic fuels and fuel cells, bio-economy, agriculture), socio-economic issues, lifestyle and behavioural aspects (see Figure 5 in Annex 2). However, it is not clear to what extent the additional investment needs estimated by the modelling covers the finances necessary for R&I of the emission reduction technologies or the management of stranded and decommissioned assets, which may increase the investment needs across scenarios.

1.3.2 Social impacts

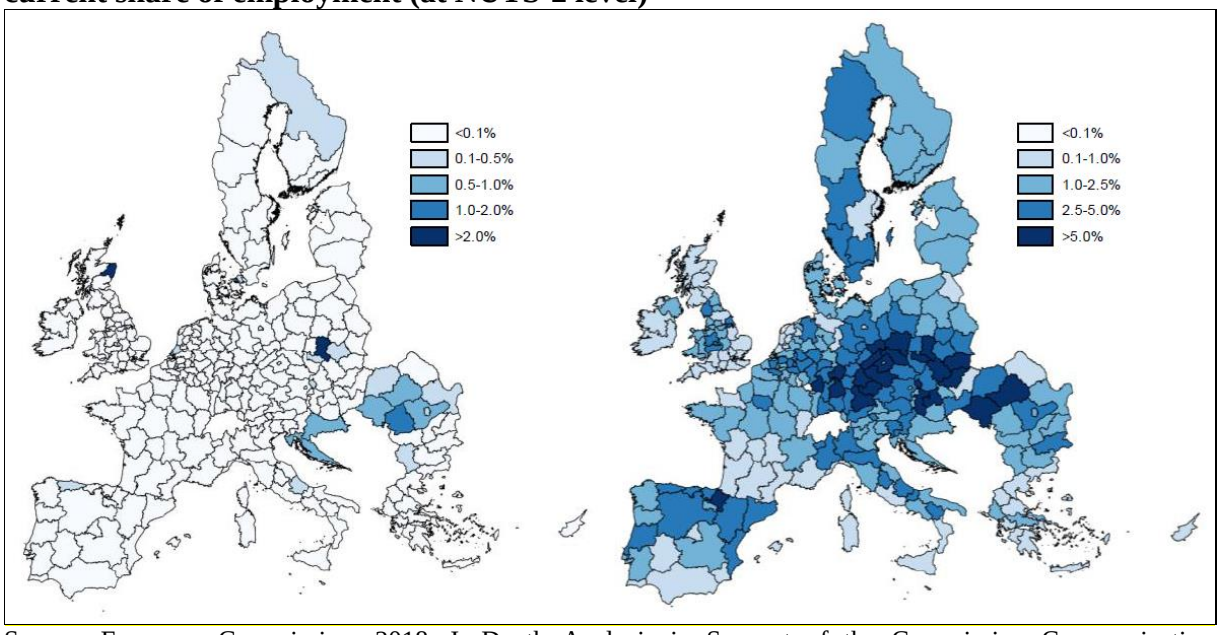
One of the key social impacts for all scenarios is the effect on employment resulting from the varying ways GHG emission reduction influences labour demand in the different economic sectors. The modelling for the LTS decarbonisation and climate neutrality pathways suggests that aggregate employment is not affected by 2050 but its sectoral composition evolves. The transition to a low-carbon economy is expected to shrink employment in fossil fuel sectors (e.g. mining, extraction, power generation) but to increase the number of jobs in RE and EE sectors. This shift is expected to have a positive impact on employment in the EU for several reasons: mining, extraction and power generation constitute a small share of EU-level employment, while the RE sector is more labour-intensive. Additional jobs are expected also in the construction and agriculture sectors as a result of the needs to make buildings more energy efficient and meet the demand for biomass (for details see Table 7 in Annex 2).

The transformation of labour demand will likely be accompanied by a need for new or different skills, which in turn might have effects on salaries and income distribution. The demand for skills is already evolving as a result of digitalisation, automatization and demographic changes but the transition to

climate neutrality might further alter the type of skillset needed for workers across sectors. For instance, it is expected to affect the task profiles of construction workers, electro-engineering workers, drivers and vehicle operators, farmers, machine and plant operators and manufacturing workers. Therefore, training and support for 'upskilling' or 'reskilling' will be needed both to meet the demand for new skills and help workers find jobs in new sectors.

However, these employment impacts are likely to vary between Member States or regions (both in terms of jobs and skills) depending on their production specialisation. Currently few EU regions have high employment rates in the mining and extraction sectors but nearly all regions have workers employed in sectors that are likely to be transformed by the climate neutrality transition (e.g. manufacture of chemicals/chemical products, basic metals, motor vehicles) as exemplified by the following figure.

Figure 1: Regional exposure to sectors that will decline (left) or transform (right) as current share of employment (at NUTS-2 level)



Source: European Commission, 2018, In-Depth Analysis in Support of the Commission Communication COM(2018) 773: A Clean Planet for all, A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy, Section 5, p. 232.

The scenarios will also have diverse impacts on households and consumers. The implementation of one of the most ambitious scenarios (1.5 LIFE) would require targeted actions to influence consumer choices through awareness raising and information campaigns, eco labels and standards. Nevertheless, choices such as preference towards active modes of transport (walking, cycling), public or shared transport, more resource efficient products or dietary changes may have positive impacts not only on the environment and climate change but also on human health. Furthermore, the EE scenario will require significant investments

in the residential sector to implement EE measures, while energy expenses are expected to grow. Energy-related expenses as a share of household income have grown since 2000 and by 2015 represented about 7.3% on average at the EU level. This share is expected to rise up to 7.5% on average by 2030 under all scenarios before decreasing afterwards as a result of the decarbonisation measures. By 2050 those expenses are expected to be 5.6% of the household income on average (see Figure 6 in Annex 2), however they are likely to vary significantly across Member States and income groups as well as scenarios (see Figure 7 in Annex 2).

All these potential impacts highlight the need to develop policies and actions that can support those negatively affected by the options in the LTS scenarios and help them adapt to the climate neutral economy, or in other words the climate neutral transition should also be a socially 'just transition' as well.

1.4 Consistency of the LTS scenarios with the IPCC 1.5 Report

The 2018 IPCC Special Report[37] explored the impacts of global temperature increase of 1.5°C above pre-industrial levels. The report focused on summarising available information about two main pathways (stabilising global temperature rise at 1.5°C by 2050 or by 2100[38]) together with their impacts on investments, social development, natural and human systems. Compared to the LTS In-depth Analysis, the IPCC 1.5 Report provides fewer details about specific decarbonisation and climate neutrality options, scenario set-up and modelling but reports largely the same outcomes for the key GHG emitting sectors.

Like the LTS scenarios, the IPCC pathways cover carbon dioxide removal technologies as net zero emissions are expected to be dependent on CO_2 removal through afforestation, the LULUCF sector, CCS/CCU and BECCS. The estimated additional annual average investment to reach 1.5°C is around USD 2.4 trillion in the period 2016-2035 (representing about 2.5% of world GDP) or about 12% more than in 2°C pathways, which is comparable to the estimates in the LTS scenarios[39]. However, direct comparison between the estimated

[37] IPCC, 2018, Global Warming of 1.5°C: An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.

[38] The IPCC reports that any pathway, which allows global warming to exceed 1.5°C by the end of the 21st century is not considered as a 1.5°C pathway. However, under the so-called 'overshoot' alternative, temperature rise can exceed 1.5°C by mid-century but return below that level by the end of the century.

[39] According to comparisons reported in the LTS In-depth Analysis.

emission reductions between the LTS and the IPCC 1.5 Report are difficult as the latter compares those to 2010 levels, indicating a 45% decrease of global net anthropogenic CO_2 emissions by 2030 and reaching net zero around 2050.

Another difference is that the IPCC 1.5 Report devotes special attention to links between climate change impacts and poverty and analyses the synergies and trade-offs between the 1.5°C pathways and the attainment of the 2030 Sustainable Development Goals (SDGs)[40]. In particular, it concludes that limiting global warming to 1.5°C would makes it easier to achieve many aspects of sustainable development and the specific SDGs, particularly in relation to eradicating poverty and reducing inequalities. Moreover, significant synergies exist between mitigation and adaptation actions and advancing sustainable development. For instance, mitigation and adaptation benefits for agriculture and health can advance SDGs 1 (extreme poverty), 2 (hunger), 3 (healthy lives and well-being) and 6 (clean water). Actions to enforce ecosystem- and community-based adaptation together with incorporation of local knowledge can contribute to SDGs 5 (gender equality), 10 (reducing inequalities) and 16 (inclusive societies).

However, some trade-offs between the mitigation options consistent with 1.5°C global warming and sustainable development also exist. These trade-offs stem from the fact that these mitigation pathways require significant changes to current systems with potential risks that are higher for vulnerable groups and areas. For example, changing energy systems to incorporate more biomass may shift or increase pressures on water and land resources in conflict with SDGs 6 (clean water) and 15 (life on land). Even though the potential co-benefits outweigh the trade-offs, potentials risks to sustainable development arising from the transition to a climate neutral economy should be carefully managed. The LTS In-depth Analysis cites the findings of the IPCC 1.5 Report on interactions with SDGs[41] in the context of the international implications of the EU LTS but does not provide further details.

Nevertheless, the European Commission published a 'reflection paper' on how to achieve sustainable development objectives in the EU and more particularly the possible policy pathways (see Box 2). The policy foundations considered in this reflection paper touch upon some cross-cutting issues relevant for the LTS including the circular economy, sustainability in the agriculture, energy, buildings and transport sectors. Furthermore, the importance of achieving a just

[40] IPCC, 2018, Global Warming of 1.5°C: An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty, Chapter 5.
[41] Section 5.7.

transition is highlighted as another relevant aspect for meeting the SDGs and sustainable development in general. Even though the LTS and the sustainable development reflection paper are largely different types of documents, they highlight the cross-cutting nature of climate and environmental sustainability and the various synergies that can be achieved when pursuing both goals simultaneously.

Box 2: European vision of sustainable development[42]

In January 2019, the European Commission published a 'Reflection Paper Towards A Sustainable Europe by 2030' that aims to launch a debate on sustainable development. It identifies the key policies and enabling conditions needed to transition to sustainability and outlines policy scenarios on how the UN SDGs can be considered in the EU policy framework.

According to the reflection paper, key policies for achieving sustainability concerning the circular economy, agricultural sustainability, future-proofing energy, buildings and transport and a socially fair transition. The success of these policies depends on a number of horizontal enablers such as:

- Education, science, technology, R&I and digitisation;
- Finance, pricing, taxation and competition;
- Responsible business conduct, corporate social responsibility and new business models;
- Open and rules-based trade;
- Governance and ensuring policy coherence at all levels.

While the reflection paper does not outline sectoral options for future development (i.e. scenarios in the sense of the LTS), it proposes three 'scenarios' about the different ideas on how the SDGs should be treated in the EU policy framework with the purpose of starting a debate. The three possibilities for reaching the SDGs are:

- an overarching EU SDG strategy to guide all the actions of the EU and its Member States;
- continued mainstreaming of the SDGs in all relevant EU policies by the Commission, but not enforcing Member States' action;
- putting enhanced focus on external action while consolidating current sustainability ambition at EU level.

[42] European Commission, 2019, Reflection Paper Towards A Sustainable Europe by 2030.

2. Part 2: The role of LRAs in the EU Long Term Strategy

As Part 1 of this report shows, limiting the temperature rise to 1.5°C or even well below 2°C as laid out by the Paris Agreement will require substantial efforts from all sectors. In this 'all hands on deck' situation, the contribution of LRAs will be crucial. They will drive much of the change needed and at the same time, they will be level of government where the impacts of the changes, at times disruptive, will be most acutely felt. LRAs play an important role in both contributing to mitigation and preparing for adaptation. It is therefore necessary to consider the potential implications of the LTS on LRAs. This Part looks at how the LTS and its In-Depth Analysis incorporate the role of LRAs as actors of change in the vision set out in the LTS.

The analysis in this section makes a distinction between urban and rural areas when relevant, given that urban and rural areas differ in their demographics, context and particular challenges they face. These differences mean that urban and rural areas will face different challenges and opportunities in responding to climate change and supporting the transition outlined by the LTS: urban areas and cities are at the centre of clean mobility, energy efficiency and innovation; rural areas will be key to sustainable management of natural resources and food production, bio-economy and carbon sinks.

2.1 The role of LRAs in the LTS

While the LTS In-depth Analysis mentions some actions LRAs can take, it does not specifically focus on the role of LRAs in the different scenarios. Therefore, this section summarises the explicit recognition of the LRAs in the LTS and explores the further opportunities for their contribution that are not explicitly mentioned in the LTS and its In-Depth Analysis, linking those to specific LTS scenarios where possible.

The LTS dedicates a specific section to the role of local authorities and citizens, recognising them as one of the key elements of an enabling framework fora achieving the transition to climate neutrality. However, the focus on these two groups – citizens and local authorities – is limited to the impact of consumer choices and citizens' lifestyles, the role of urban and spatial planning, and adaptation. However, it can also be argued that LRAs play a cross-cutting role in all initiatives and aspects of the enabling framework that are mentioned in the LTS.

The LTS In-depth Analysis also focuses on the role of cities as key agents of change and acknowledges initiatives such as Covenant of Mayors and C40. It also dedicates a specific section on the impact of change on certain regions, especially those that host economic sectors which will decline or fundamentally transform (see section 1.3.2 above) under decarbonisation scenarios. However, the main focus remains on cities with relatively little attention to challenges and opportunities related to rural areas.

Apart from these specific sections in both documents, the LTS also recognises the local aspects of climate change and the transition to climate neutrality. On the one hand, the local level can benefit from the changes - the greening of economy will create jobs and/or the decentralisation of energy production will bring back employment to the local level. On the other hand, the local level will have to bear the actual burden of the change - considerable investments will have to come from households and private businesses and the negative repercussions of the transition might be felt more acutely at some places compared to others. For instance, some regions that heavily depend on industries and economic sectors that are expected to shrink or transform will face bigger challenges, at least in the transition period. The LTS also stresses that steps should be taken to ensure no regions experience energy poverty and that no group within the society bears disproportionate costs. The Strategy therefore emphasises that the transition should be a 'just transition' underlining the social impacts of climate policy responses, which can be felt the most at local level.

Other possible implications for LRAs, although implicit, can be found in the LTS, especially in the section that puts forward seven 'strategic building blocks' of action to decarbonise the EU and achieve net zero emissions by mid-century as well as in the set-up of the LTS scenarios (outlined in section 1.1 of this report). LRAs can support the main drivers and enabling conditions for low-carbon transition thanks to their responsibilities to oversee territorial and urban planning, manage transport and mobility, adopt and enforce legislation at the regional- or local-level and finance local projects. In addition, LRAs are well placed to lead by example, test best practices and pilot projects and raise awareness at the local level through engagement with citizens and SMEs.

The following sections briefly explore the potential role of LRAs in these building blocks and scenario aspects in more detail.

2.1.1 Energy efficiency including zero emission buildings

A successful transition to a decarbonised economy necessitates energy efficiency. As pointed out both in the LTS and its In-Depth Analysis, further energy efficiency improvements are required in all scenarios. This will require

new zero emission buildings, renovations to existing building stock and higher performing construction materials for improved thermal insulation.

Efforts to achieve energy efficiency have considerable implications for the LRAs, especially given their competences to in territorial and urban planning. First of all, they are the best placed to devise solutions tailored to the specific local needs. In the same vein, they might utilise the means that are at their disposal to encourage the construction of zero emission buildings, the renovation of existing ones, the update of energy efficient technologies in the buildings and even the use of more energy efficient appliances. They can do this through a variety of measures such as green public procurement, policies that encourage renovation of existing housing stock, pilot projects to lead by example and awareness raising among citizens and businesses about energy efficiency in all sectors. Furthermore, local and regional authorities themselves own a significant share of the building stock, which provides an opportunity for them to lead by example and support the shift to zero emission buildings. This is particularly relevant for the scenarios that rely on demand-side measures and lifestyle choices, namely EE, CIRC and 1.5 LIFE, LRAs.

Furthermore, the LTS states that costs related to energy transition for buildings will continue to grow, at least until 2030 and this might present a disproportionate challenge for certain regions and certain parts of the population. LRAs are better positioned to take into account such vulnerable groups as they are closer to the local context and can provide valuable input when it comes to the design of policy responses to this challenge (for further details see section 2.1.7).

2.1.2 Renewable energy and electrification

In line with the scenarios, the LTS calls for a radical change in the energy production systems – a switch towards the use of more RES and electricity as the dominant sources of energy. This is likely to be accompanied by a decentralisation of energy systems and a decrease of energy imports. Consequences of such a transition are manifold: prosumers will become important, new business opportunities in renewable energies will be available, local energy production will support employment, other sectors such as transport, heating and industry will be presented with new opportunities. Nevertheless, several factors have to come together to make the transition possible, including making the power systems flexible and smarter, increasing interconnectivity and storage.

Although conventional energy markets are still largely regulated in a centralised manner, often at the national level, LRAs can have an important role to play as

the deployment of RES grows. In the Member States where energy markets are designed in a way to allow residents or local energy communities to produce their own electricity from renewable resources and to commercialise the surplus they generate via smart-grids, energy supply has become more decentralised[43]. Such decentralisation efforts have the potential to raise awareness among citizens, create employment and added value for the local economy and drive overall energy prices down, cushioning the most vulnerable citizens against energy poverty[44]. Where the national legislative framework allows it, LRA policy choices can contribute to such initiatives. LRAs can develop policies to encourage and facilitate local energy production and distribution. To enable this, regulatory and administrative barriers need to be addressed to support local energy communities[45].

In the same vein, LRAs can contribute to maximising the use of RES and electricity by playing their part in the development of the necessary energy infrastructure. Smart grids, digital management and storage are becoming increasingly important in the exploitation of renewable energy. The planning of cities, decisions regarding spatial planning and investments in innovative solutions are also critical. Because such infrastructure investments are inherently long-term, decisions made today at the local level will have direct impact of how the cities and rural communities of tomorrow will look like.

Last but not least, the growth of renewable energy and electrification in all scenarios, but especially in ELEC, provides a unique opportunity for economic development at the local level. LRAs can support this through promotion and development of specific RES based on the local resources of different regions. For instance, coastal regions can explore the opportunities to use offshore wind, tidal or ocean energy that are unique for their locations. Similarly, rural regions can develop capacities for bioenergy.

2.1.3 Clean, safe and connected mobility

The Strategy recognizes the contribution of the transport sector to the GHG emissions in the EU and identifies several key areas for action, including electrification of the vehicle fleet, a better connected train network and aviation that relies on alternative fuels. Beyond the fossil-free transport models, clean mobility will necessitate the use of digital technologies, intermodal operability and smart management of the systems as a whole. Short-distance journeys will

[43] Hentschel, J. et al. 2018, Descriptive study of local energy communities.
[44] Gancheva M. et al. 2018, Models of Local Energy Ownership and the Role of Local Energy Communities in Energy Transition in Europe.
[45] Gancheva M. et al. 2018, Models of Local Energy Ownership and the Role of Local Energy Communities in Energy Transition in Europe.

have to be radically transformed in the cities towards cleaner and safer alternatives such as cycling and walking. Consequently, the LTS recognises cities as an important actor in innovating new ways of mobility as they will host 75% of the world population and a dominant share of journeys in the future

City authorities, and urban areas in general, will have an important role to play in encouraging clean mobility through the use of several instruments at their disposal: green procurement to renew public transport fleets; investments in better and smarter infrastructure and digitalisation to better manage traffic flows; policies that encourage the uptake of cleaner vehicles and healthier modes of mobility. In a similar note, the LTS In-depth Analysis points out to the multiple local initiatives that incorporate citizens' engagement to build cleaner cities, which have very fast positive feedback loops such as improvements in air quality. These contributions can be further strengthened, especially in the cities with the use of appropriate and innovative urban planning. Furthermore, the uptake of fossil-free transport alternatives will require a new or transformed infrastructure that allows the circulation of electric vehicles or those powered by H_2 and e-fuels. Therefore, LRAs will need to not only plan the mobility systems within their areas but also ensure local infrastructure can meet the future needs of the transport sector.

Beyond intra-city mobility, rail and inland navigation will require transformation of relevant infrastructure. Such transformations have implications on land use and stress on natural resources and biodiversity. Local authorities can contribute to limiting these impacts, and minimise those impacts thanks to their knowledge about the specific contexts in which such projects will be implemented.

2.1.4 A competitive EU industry and circular economy

In line with scenarios, the LTS stresses the need to further improve recycling and re-use rates for all materials together with the use of traditional and new materials that are less energy intensive during production. A critical driver for circular economy will be the consumer demand for environmentally friendly and energy efficient materials and products.
As with demand-side measures (e.g. energy efficiency), LRAs can play an important role to push forward fundamental aspects of the circular economy. Local and regional authorities often have a strong role in waste management policy-making, planning and implementation[46], allowing for the development of policies as well as facilities that enable reuse, reclaim and recycling, ultimately

[46] OECD, 2019, Waste Management and the Circular Economy in Selected OECD Countries: Evidence from Environmental Performance Reviews (forthcoming).

growing the circular economy that is at the centre of the CIRC pathway and is critical for the most ambitious 1.5 LIFE alternative. Moreover, LRAs are best placed to develop initiatives to raise awareness among the citizens and influence their behaviour. Therefore, local policies carry a very important weight on recycling rates.

Another potential contribution of LRAs can be to encourage innovative businesses and climate-neutral industries (e.g. with specific policies or tax incentives) and steer the transformation of local economic sectors into low-carbon ones e.g. by developing industrial facilities for new processes and industries, such as those based on H_2 and e-fuels. This in return can benefit local economies in the form of job creation and innovation and serve as an opportunity for economic growth through specialisation in new sectors and technologies.

2.1.5 Bio-economy and carbon sinks

In its broadest sense, bio-economy[47] refers to the production, use, consumption, storage, recycling and disposal of biological resources. It is an essential component of the circular economy and a major pillar of action in decarbonising Europe with strong interlinks to other sectors. Therefore, the LTS emphasises: the importance of biomass as an energy source; sustainable and more efficient agriculture as a way to reduce impacts on soil and other natural resources; and agriculture and natural sinks (such as forests) to offer other benefits such as carbon sequestering and energy generation. In the same vein, farmers are recognised as important agents of change in achieving circular economy. Agriculture is responsible for an important share of GHG emissions. Farmers have an important role to play in minimising these impacts by adopting sustainable agricultural practices, investing in systems that allow the reuse of materials from the farming processes (for instance using organic waste for energy production), developing opportunities and technologies for on-farm biosequestration of carbon, and contributing to the overall sustainability of the sector.

However, the LTS points out also the possible conflicts between the use of biomass as an energy source and its important role as a carbon sink, and highlights that the demand for biomass should not jeopardise the existing forest stock. Another possible challenge is related to land use changes, driven by

[47] The European Commission defines bio-economy as '*the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy. Its sectors and industries have strong innovation potential due to their use of a wide range of sciences, enabling and industrial technologies, along with local and tacit knowledge'* in European Commission, 2012, Innovating for Sustainable Growth: A Bioeconomy for Europe, COM(2012) 60.

increased demand for biomass. It is important that decisions are made to optimise the use of scarce land while avoiding further stress on natural resources and biodiversity (see section 1.2).

LRAs, especially in rural areas, will be central to the development of a sustainable bio-economy. As suggested in the Opinion of the Committee of Regions on the 2050 Energy Roadmap, efforts aiming to transition to clean energy systems will have major impacts on agricultural practices and forestry policies, both of which are closely linked to rural areas[48]. LRAs can play decisive roles in shaping farming practices as well. The communication from the Commission on the future of the Common Agricultural Policy (CAP) strongly emphasise enhanced subsidiarity[49] and greater flexibility for the Member States to manage their CAP funding[50], which will have direct impacts on the local level. That entails important decisions such as selecting the conditions for receiving direct payments and setting priorities for Rural Development Funds being developed in a more decentralised manner. These decisions have direct impact on farmers' practices, therefore they can be used to encourage sustainable agriculture, and LRAs contribution is necessary to inform Member State policies. Furthermore, LRAs can engage in educational and awareness raising activities among farmers through new initiatives and within existing structures such as Farm Advisory Services. Agriculture remains strongly context-dependant with differences among climate, geography and culture. Therefore, local authorities are in the best position to inform decisions and foster the solutions best suited to local conditions.

2.1.6 A smart and inter-connected infrastructure network and CCS

Closely related to smart mobility, decarbonisation of the economy and an ultimate transition to climate neutrality necessitate infrastructure networks that connect Europe in an efficient and reliable way. The LTS puts emphasis on the need for building infrastructure networks that support connectivity between the regions of Europe, both in terms of energy distribution and transport. The interoperability of rail transport and integration of different transport modes are important components of the connectivity.

Interconnectivity of regions in general and urban nodes in particular has important implications for the local level. Cities as built environments are particularly important in this regard. From connections between industrial hubs

[48] Committee of the Regions, 2012, Opinion on Energy Roadmap 2050.
[49] Overarching objectives of the CAP post-2020 reform involve a more sustainable agriculture with smart and resilient outlook, contribute to the environmental and climate objectives and strengthen rural areas both socially and economically.
[50] European Commission, 2017, The Future of Food and Farming, COM(2017) 713.

to smart traffic management, they are the primary landscape where decisions are taken to improve the interconnections. LRAs can take the European-level approach into account when planning for transport infrastructure as to how to integrate local projects within wider initiatives (for instance the TEN-T programme). Furthermore, their efforts regarding clean mobility, multi-modal transport, and better spatial planning will also contribute to a smart and connected network.

CCS will be another important building block for action and a focus in developing energy networks, as remaining GHG emissions will have to be tackled in order to reach climate neutrality mid-century. Within their responsibilities to develop local infrastructure LRAs may also explore the opportunities to support the development CCS/CCU and BECCS facilities. While the development of these technologies has been slower than expected, the LTS anticipates their contribution to climate neutrality and the development of the necessary network infrastructure may involve LRAs, particularly in relation to their roles in environmental permitting and spatial planning.

2.1.7 Horizontal role for the LRAs

LRAs have an important role to play in all pathways to climate neutrality, especially for setting up an enabling framework that can support a variety of options, mitigating potentially negative impacts and risks of the low-carbon transition to ensure a 'just transition' and realising the benefits and opportunities that it brings. LRAs can contribute to putting in place and implementing all main enabling conditions behind the LTS scenarios (see section 1.1.2 for details) often in close cooperation and coordination with other levels of governance. A particularly important role for LRAs will be to support the development of the infrastructure required for the deployment of emission reduction technologies and drivers of the transition (as outlined in the previous sub-sections) and the uptake of demand-side measures. Moreover, the two most ambitious scenarios rely on a combination of technologies and measures from all other scenarios highlighting the fact that climate neutrality cannot be achieved through one technology or measure alone but requires a mix of solutions. Therefore, the success of either 1.5^{o}C scenario will rely on both development of the necessary infrastructure and a promotion of more sustainable lifestyle choices, for both of which LRAs are well placed to contribute.

One of the most important roles for LRAs in the LTS scenarios will be to connect with citizens and steer demand-side measures at the local level. Through engaging with local stakeholders LRAs can harness ideas and momentum from citizen action. At the same time, being close to the end-users, LRAs can influence citizen and business choices towards more energy and resource

efficient lifestyles. The success of environmental innovations related either to new concepts or changes to existing habits depends on the readiness and willingness of stakeholders to accept and support such actions. Consequently, involving stakeholders in the decision-making process is particularly important for ensuring the acceptability and success of policies. Through inclusive processes such as community-led local development (CLLD) or 'co-creation' citizens can be involved in the development, design and even implementation of local policies increasing the sense of ownership and commitment to these policies[51]. This in turn can be critical for their success. LRAs are best placed to adopt such approaches and engage with local stakeholders to ensure that: 1) unique local knowledge and experience to find solutions to specifically local challenges are harnessed; 2) policies pursuing climate neutrality have the support of local communities. The importance of local authorities is also highlighted in the IPCC 1.5 Report that points out local governments can design effective local responses to ensure community engagement and more effective policies around energy and vulnerability reduction[52].

In addition to their dual role to support infrastructure development and sustainable behavioural choices, LRAs will also be at the forefront of managing the impacts of the climate neutrality transition. Therefore, LRAs will have to ensure benefits brought about by the transition are reaped while threats and potentially negative impacts are managed. For instance, the deployment of EE measures can stimulate the local construction sector but it may increase the risks to energy poor or vulnerable households that may be unable to invest in EE measures. Similarly, the development of local RES and the transformation of local industries into low-carbon ones can be opportunities for economic development but may also result in stranded assets or a decline of certain sectors and/or work skills. Therefore, a key responsibility for LRAs will be to ensure local socio-economic systems are well prepared for the transition to climate neutrality, e.g. through measures for upskilling or reskilling the local workforce, training and support to emerging economic sectors. Rural communities will have a further responsibility to manage potential risks from the climate neutrality transition to the environment and particularly biodiversity and ecosystems.

[51] Gancheva, M. et al. 2018, Towards an 8th Environment Action Programme – Local and regional dimension.
[52] IPCC, 2018, Global Warming of 1.5°C: An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty, Chapter 4.

2.2 Achieving the vision: Barriers for LRAs

The LTS recognises a role for LRAs in the ambitious transition that Europe will undergo in the coming decades. This section now considers the barriers faced by LRAs in supporting the LTS, and possible enabling factors.

One important barrier is related to financial resources. All the opportunities that the decarbonisation and climate neutrality pathways offer will require significant investments. The LTS states that around 2.8% of the GDP (as opposed to 2% today) will have to be invested in energy and related infrastructure to achieve decarbonisation and ultimately climate neutrality of the economy[53]. As a result, substantial investment from both private and public sectors will be needed. LRAs face challenges in accessing various public and private climate finance options[54]. However, these investments are expected to be at least partially compensated by costs savings in various sectors, for instance in public health expenditure[55]. The LTS partially addresses the necessary finance emphasising the importance of the financial resources needed, without referring to the particular challenges that the LRAs can face in this regard.

In the same vein, LRAs can also struggle to fulfil their contribution to LTS due to limitations in institutional capacity. Lack of appropriate human resources – both in terms of staff numbers and appropriate expertise – can hinder the implementation of policies at the local level. As mentioned above, some regions will undergo substantial changes due to transformation of entire fields of economic activity. The challenges related to institutional capacity can be particularly important in these regions, where more resources will be needed.

Another important challenge is the legal framework, which might not allow LRAs to fully contribute to the ambitious goals set out in the LTS. A noteworthy example is the legal framework of energy markets in the Member States. As mentioned earlier, local communities have the potential to contribute to the deployment of renewable energy. However, national framework and regulations can be an obstacle. LRAs are not able to address such challenges at a local level and will require policy action at the national or EU level.

[53] COM(2018) 773.
[54] Rossi, L. Gancheva, M. and O'Brien, S. 2017 Financing climate action: opportunities and challenges for local and regional authorities.
[55] COM(2018) 773.

2.3 Role of LRAs in previous documents and change over time

In order to understand how the role for LRAs in strategic EU documents has evolved over time, the study reviewed other EU strategic policy documents relevant to climate change, including:

- Energy Strategy for 2020 (2010)[56];
- 2050 Energy Roadmap (2011)[57];
- Transport White Paper (2011)[58];
- Roadmap for Competitive Low Carbon Economy (2011)[59];
- Roadmap to a Resource Efficient EU (2011)[60];
- Green Paper 2030 Framework for Climate and Energy Policies (2013)[61];
- The 7th Environmental Action Program (EAP) (2013)[62];
- Towards Integrated Strategic Energy Technology (2015)[63]; and
- EU Strategy on Low Emission Mobility (2016)[64].

Although not all of these documents are entirely concerned with climate change or decarbonisation, they all have important overlaps with the LTS.

First, among the documents analysed the only one which specifically dedicates a section to challenges at the local level is the 7th EAP, stating that the considerations at the local level have to be integrated in the policy design in a systemic way. To a more limited extent, the Green Paper also recognises the differences between the Member States and states that the policy design must account for different capacities of regions and citizen groups to invest and adapt.

The main role of LRAs as agents of change can be seen in the previous documents as well. This is true regardless of the focus: from clean energy to

[56] European Commission, 2010, Energy 2020 A strategy for competitive, sustainable and secure energy, COM(2010) 639.
[57] European Commission, 2011, Energy Roadmap 2050. COM(2011) 885.
[58] European Commission, 2011, White Paper: Roadmap to Single European Transport Area - Towards a competitive and resource efficient transport system, COM(2011) 144.
[59] European Commission, 2011, A Roadmap for moving to a competitive low carbon economy in 2050, COM(2011) 112.
[60] European Commission, 2011, Roadmap to a Resource Efficient Europe, COM(2011) 571.
[61] European Commission, 2013, Green Paper: A 2030 Framework for Climate and Energy Policies, COM(2013) 169.
[62] Decision 1386/2013/EU […] on a General Union Environment Action Programme to 2020 'Living well, within the limits of our planet'.
[63] European Commission, 2015, Towards an Integrated Strategic Energy Technology (SET) Plan: Accelerating the European Energy System Transformation, CCOM(2015) 6317.
[64] European Commission, 2016, A European Strategy for Low-Emission Mobility, COM(2016) 501.

resource efficiency, most of the documents recognise the important role that local and regional authorities can play. Several of the documents (e.g. the 2020 Energy Strategy, the Roadmap to a Competitive Low Carbon Economy, the Transport White Paper and the 2050 Energy Roadmap) recognise the role of local authorities in leading by example: e.g. in the transition to clean vehicles, investing in smart energy grids, designing urban environments to encourage alternative transport modes, and reducing transport emissions. The 7th EAP emphasises the importance of local authorities in decisions about spatial planning and land use. The EU Strategy on Low Emission Mobility also underlines the role of LRAs, especially in cities, in driving change and recognises public procurement as an important demand-side tool.

There is less emphasis on the need to account for the differences between the regions and integrating the local aspects into policy-making processes in a systemic way. The Resource Efficient EU Roadmap, the Roadmap to Competitive Low Carbon Economy and the 2030 Green Paper state that the regional differences should be considered in designing relevant policies.

Most of the documents analysed fail to mention the initiatives already put in place by the LRAs, as noted by the Committee of the Regions[65]. That being said, others recognise the good practices and effective work that has been going on at the local level. The 2020 Energy Strategy, the Communication towards an Integrated Strategic Energy Technology and the EU Strategy on Low Emission Mobility encourage the EU to build on the good work already put in place by regional authorities, mentioning initiatives like Covenant of Mayors and CIVITAS.

Another important aspect largely missing from the documents is the attempt to lay down a strategic vision to support the LRAs in their efforts. There is little attention paid to the possible contribution of EU level initiatives, national and EU financial instruments as well as legal and policy frameworks in supporting LRAs in supporting EU-level initiatives. Some documents (e.g. the 2020 Energy Strategy, the Resource Efficient EU Roadmap and the 7th EAP) mention the important of capacity building and knowledge sharing and highlight the need to encourage the use of Cohesion Policy funds by LRAs. Consideration of tools to support LRAs in implementation is rarely an integral part of the strategic visions.

[65] European Committee of the Regions (2012), Opinion on the Energy Roadmap 2050.

3. Part 3: National Energy and Climate Plans as tools to implement the EU Long Term Strategy

With the Governance Regulation Member States have new planning tools for outlining their plans and actions for decarbonisation. This Part looks at the possible ways the new NECPs can serve as tools for implementation of the LTS.

3.1 Summary of the NECPs structure

3.1.1 The Governance Regulation and Clean Energy package: a new European framework

The NECPs are a vital part of the Regulation on the Governance of the Energy Union and Climate Action, which entered into force on 24 December 2018 and is commonly known as the Governance Regulation[66]. This Governance Regulation brings together planning, monitoring and reporting obligations on Member States regarding climate policy and the Energy Union. In particular, its major aims include:

- building a strategy for meeting 2030 climate and energy targets and Paris Agreement obligations across different Member States;
- setting up a stable framework that encourages long-term investment;
- making reporting and monitoring simpler and harmonising them between Member States, by bringing them under one regulation[67].

The Governance Regulation is a part of the *Clean energy for all Europeans* package[68], a policy framework that contains the binding climate and energy targets for 2030 and specific measures for the building sector and electricity. As well as the Governance Regulation, the Clean Energy package contains directives on energy efficiency, energy performance in buildings and renewable energy, as well as pending legislation on electricity market design, risk preparedness and energy regulators.

[66] Regulation (EU) 2018/1999 […] on the Governance of the Energy Union and Climate Action.
[67] Reporting is currently divided between different directives and regulations. The Governance Regulation brings them together into Integrated national energy and climate progress reports (see Governance Regulation Chapter 4 on Reporting).
[68] DG ENER, Commission proposes new rules for consumer centred clean energy transition website.

3.1.2 The NECPs: a reporting, monitoring, and harmonisation tool based around the Energy Union

The NECPs are the streamlining measure to bring Member States' energy and climate strategies together and ensure that they have a realistic plan for reaching EU and Paris-Agreement targets. Member States were asked to submit their draft Plans by the beginning of 2019. The NECPs cover a ten-year period and function on a rolling basis: new versions will be submitted before the end of the current period for the following ten years. The plans will also be updated halfway through the implementation period. For the 2020-2030 period they will be updated by 2024. This is one year earlier than the EU's updated NDC under the Paris Agreement is due to be sent, so this would in theory allow the EU time to review Member State ambitions before submitting the NDC (see Part 4). Table 8 in Annex 3 details the key dates for submitting and updating the NECPs.

Given their function as a monitoring tool, the NECPs are based on an iterative process between the Member State and the European Commission, where draft plans are assessed and discussed and their implementation is followed by the Commission, which can offer recommendations if a Member State risks not meeting its defined targets.

A template for the structure of the NECPs is defined by the Commission in Annex I of the Governance Regulation. Member States are asked to (1) give an overview of the preparation of the plan, (2) state their climate and energy objectives, (3) describe policies and measures planned for reaching these objectives, (4) give a snapshot of the current situation and projections with existing policies, then (5) assess the impact of existing and planned policies. The Plan finishes with a statistical section with projected trends to 2040 for various macroeconomic, energy and climate indicators.

For each of sections two to four, the information asked of the Member States is organised around the five dimensions of the Energy Union:

- decarbonisation;
- energy efficiency;
- energy security;
- internal energy market;
- R&I and competitiveness.

A table summarising the structure of the plans is provided below.

Table 3: Structure for integrated NECPs

Part 1: General Framework **Section A: National plan**
1 Overview and process for establishing the plan
1.1 Executive Summary 1.2 Overview of current policy situation 1.3 Consultations and involvement of national and Union entities and their outcome 1.4 Regional cooperation in preparing the plan
2 National objectives and targets
2.1 Dimension decarbonisation 2.1.1 GHG emissions and removals 2.1.2 Renewable energy 2.2 Dimension energy efficiency 2.3 Dimension energy security 2.4 Dimension internal energy market 2.4.1 Electricity interconnectivity 2.4.2 Energy transmission infrastructure 2.4.3 Market integration 2.4.4 Energy poverty 2.5 Dimension Research, innovation and competitiveness
3 Policies and Measures
3.1 Dimension decarbonisation 3.1.1 GHG emissions and removals 3.1.2 Renewable energy 3.1.3 Other elements of the dimension 3.2 Dimension energy efficiency 3.3 Dimension energy security 3.4 Dimension internal energy market 3.4.1 Electricity infrastructure 3.4.2 Energy transmission infrastructure 3.4.3 Market integration 3.4.4 Energy poverty 3.5 Dimension research, innovation and competitiveness
Section B: Analytical basis
4 Current situation and projections with existing policies and measures
4.1 Projected evolution of main exogenous factors influencing energy system and GHG emission developments 4.2 Dimension decarbonisation 4.2.1 GHG emissions and removals 4.2.2 Renewable energy 4.3 Dimension Energy efficiency 4.4 Dimension energy security 4.5 Dimension internal energy market 4.5.1 Electricity interconnectivity 4.5.2 Energy transmission infrastructure 4.5.3 Electricity and gas markets, energy prices 4.6 Dimension research, innovation and competitiveness
5 Impact assessment of planned policies and measures
5.1 Impacts of planned policies and measures on energy system and GHG emissions and removals, including comparison to projections with existing policies and measures 5.2 Macroeconomic and, to the extent feasible, health, environmental, employment and education, skills and social impacts, including just transition aspects 5.3 Overview of investment needs 5.4 Impacts of planned policies and measures described in section 3 on other Member States and regional cooperation
Part 2: List of parameters and variables to be reported in Section B of National Plans

Source: Summary based on Annex I of the Governance Regulation (Regulation 2018/1999).

3.1.3 Multilevel climate and energy dialogue

Whilst the NECPs are by definition submitted as a national-level planning document, there is some provision for involvement of regional and local levels. Article 11 of the Governance Regulation states that Member States 'shall establish a multilevel climate and energy dialogue'. This dialogue would involve local authorities as well as other stakeholders such as business representatives and civil society organisations. It is stated that the NECPs and the national long-term strategy could be discussed as part of the dialogue. Dialogue with local level is also stipulated as part of the structure for the plans, under section 1.3 (see Table 3).

Several organisations have picked up on the potential of the multilevel dialogue platforms and have encouraged Member States to respect this part of the Governance Regulation that involves the local and regional level[69]. In addition to this, an EU LIFE-funded project has been set up to help implement the consultation aspect of the plans. The PlanUp project will work on the monitoring and implementation of the plans during the decade 2020-2030 in five Member States[70], particularly focussing on agriculture, building and transport sectors. It will collect data, make this available to the public on an online platform and organise dialogue with local and regional authorities and other stakeholders. It is hoped that best practice from the project will be used as a model for the multilevel energy and climate dialogues in other Member States[71].

3.2 Consistency of the NECP structure with the LTS

This section compares the pathways proposed by the LTS with the reporting and monitoring capability of the NECPs, in order to assess how well-adapted they are as a tool for helping the EU and Member States to plan and coordinate climate efforts. The section is divided into decarbonisation factors common to all scenarios and enabling conditions to allow them to be put in place.

3.2.1 Baseline and shared assumptions

As described in Part 2 of this study, the analysis behind the LTS considers eight different decarbonisation pathways or scenarios for how the EU can contribute to keeping global temperature change below 2°C or 1.5°C by 2050. These

[69] See, for example, the open letter signed by the board of the European Covenant of Mayors and Carbon Market Watch, 2018, 'National energy and climate plans and the transition to carbon-free societies'.
[70] The countries are Spain, Italy, Poland, Romania and Hungary.
[71] PlanUp 2019, Launch of LIFE project 'PlanUp points new spotlight on EU National Energy & Climate Plans'.

scenarios are founded on a baseline that follows agreed legislation including climate and energy goals and the 2018 Governance Regulation, the Regulation founding the NECPs. In practical terms, this indicates a trajectory relying on the successful implementation of the EU's 2030 climate and energy targets[72]. However, it does not take account of national measures, planned or existing, that may be part of the NECPs, in that no attempt was made to consult Member States in order for current policies to be represented[73].

The baseline scenario is constructed to be aligned with the monitoring and reporting capacities of the NECPs, and this is indeed the case. The first ten-year NECP period ends in 2030 and the 2030 climate and energy commitments at EU level form an important part of the NECPs. Member States must show that they have planned measures and policies that will allow them to reach the 2030 targets.

As well as all being constructed upon the same baseline projections, the different 2050 scenarios share other common assumptions that would all have to be implemented in the context of any of the scenarios. These common assumptions include:

a) higher energy efficiency after 2030;
b) moderate circular economy;
c) deployment of sustainable, advanced biofuels;
d) BECCS only after 2050 in the 2°C scenarios;
e) digitalisation;
f) market coordination for infrastructure deployment;
g) significant learning by doing for low-carbon technologies;
h) significant improvements in the efficiency of the transport system[74].

As stated in section 3.1.2, energy efficiency (a) is one of the five pillars of the Energy Union; the topic is well-represented in the NECPs. Targets are requested for 2030, 2040 and 2050, along with expected trajectories for key indicators and estimates of expected energy savings and wider benefits brought by greater energy efficiency. As in the LTS, emphasis is put on improving the efficiency of building stock, with the requirement of a long-term plan for public and private building renovation. This requirement coincides with the National Building Renovation Strategy, which is included within the National Energy Efficiency

[72] The 2030 targets are: at least 40% GHG emissions reduction compared to 1990 (43% GHG emissions reduction in ETS sectors compared to 2005 and 30% GHG emissions reduction in effort-sharing sectors compared to 2005); at least 32% renewable energy share in final energy consumption and at least 32.5% of energy efficiency improvements.
[73] LTS In-depth Analysis, Sections 3 and 4.
[74] Ibid.

Action Plans. The next of these strategies is due in early 2020[75]. Also requested are measures for stimulating cost-effective deep renovation, promotion of the exemplary role of public buildings, as in the Energy Efficiency Directive[76], and removing barriers to energy-performance contracting in the public sector, means of promoting the role of local renewable energy communities.

The circular economy (b) will help to reduce the input of raw materials into industrial processes through reuse and recycling. In doing so, it will help to reduce GHG emissions and pollution by reducing the energy needed to produce commodities, particularly materials such as steel or glass or plastics. Nevertheless, the circular economy is little represented in the Energy Union and it goes unmentioned in the NECPs. This is perhaps related to the fact that this kind of measure is linked to the choices of the end-user, rather than top-down measures that can more easily be imposed. Given that space is offered for Member States to describe planned policies or measures that do not directly respond to EU-level targets, circular economy measures or specific projects could be mentioned as a part of the section on measures to improve energy efficiency, under consumer information measures.

Sustainable advanced biofuels (c) are recognised in the LTS as being particularly useful because, as well as being carbon-neutral, they can be used in existing vehicle engines and use the existing refuelling infrastructure. This means that they will be simple to implement. Whilst advanced biofuels are only mentioned directly as a potential indicator for Member States to provide uptake projections for, they are a form of renewable energy and in that sense can be extensively used by Member States within the NECP framework. Renewable energy falls under the decarbonisation pillar of the Energy Union, and is accorded a lot of space in the NECPs. In particular, the transport sector is highlighted as a sector that must be specifically addressed in the NECPs; advanced biofuels could be listed under this requirement.

BECCS, (d), has been suggested as a means of removing carbon dioxide from the atmosphere, acting as a sink. However, doubt has been cast over its usefulness for reducing CO_2 emissions[77] and the LTS only countenances using it in a 2^oC rise situation after 2050. Mention of this as a measure could be made under the section on greenhouse gas emission reduction, but it seems unlikely that this would be used in the near future.

[75] Article 4, Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency.
[76] See article 5, Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency.
[77] Christensen, J. 2018, The inherent dangers of Bioenergy with Carbon Capture and Storage (BECCS).

Digitalisation (e) is a cross-cutting development and will help to improve efficiency in terms of smart infrastructure, heating and cooling systems, and more accurate information about energy usage so that problems can be more easily located and improvements better targeted. The smart infrastructure element of this is captured in the NECP sections covering the Energy Union pillar of the internal energy market, where Member States are asked to record policies for implementing smart grids and meters, in cooperation with other Member States. Improved data and reporting facilitated by digitalisation will feed into the monitoring and projections demanded of Member States in *Part B* of the NECPs.

The LTS puts an emphasis on the importance of improving infrastructure (f), both energy and transport, at national level and through regional cooperation between Member States. The internal energy market element of the Energy Union looks at improving both national and intra-EU energy infrastructure. Modernisation projects are called for where necessary. Transport infrastructure, mentioned by the LTS as being important for emissions reduced transport, for example through the completion of the TEN-T network, can be addressed in the NECP through the development of renewable energy in transport infrastructure. Similarly then, efficiency in the transport system (h) can be addressed through the NECPs' encouragement to plan policies aimed at increasing the share of renewable energy to be used.

Low-carbon technologies (g) are particularly covered by the renewable energy sections as mentioned above. There is space here for Member States to list policies and measures that could involve new low-carbon technologies that have not been widely used in a given Member State before.

3.2.2 General enabling conditions

Section 2.1 identifies several crosscutting enabling conditions that will be necessary to accompany the decarbonisation drivers mentioned above. Research and innovation has a major role to play in the development of new technologies. The NECP provides direct encouragement for R&I through requirements from Member States for objectives for deployment of low-carbon technologies, carbon transport and storage infrastructure and the promotion of clean energy technology, reaching to the 2050 horizon.

The LTS also highlights the importance of financing options to ensure that policies and measures can be put into place. This is also a preoccupation of the NECPs, which require Member States to look at how measures and policies can be financed, including by reviewing current subsidies and financing of fossil fuels.

Demand-side action, referred to above briefly in relation to the circular economy, is an essential part of the pathways leading to net zero emissions in 2050. This element, encouraging adaptation of consumer choice, has little coverage in the NECPs. While there are references to consumer information programs[78], these are vague and not strong enough to encourage Member States to really pursue this path. Equally, whilst Member States are asked to consult with the general public, ostensibly a call for citizen-engagement, there is no reference to changing consumer behaviour.

3.2.3 Gaps in the NECPs

The National Energy and Climate Plans are built around the five dimensions of the Energy Union. They are effective for measuring the evolution of the principal indicators of the 2030 climate framework and for getting a European overview of the contributions of the different Member States.

They appear to be less effective in planning for demand-side change. The most ambitious scenarios described in the Long-term Strategy require changes in consumer behaviour. The LTS states that 'climate change can only be tackled if people actively engage, as consumers and as citizens'[79]. This can be achieved through choices made to engage with a circular economy by recycling or buying products made from recycled or reused materials, or by changing diets to include less meat, for example. The importance of consumer engagement and support for change is also mentioned in the context of energy efficiency of buildings, prosumers producing renewable electricity and consumers wanting to reduce their environmental footprints in a range of commercial decisions.

Of these points, only the encouragement of prosumers is mentioned in the template for the NECPs. Whilst it is possible for countries to mention policies and measures to promote consumers making environmentally-friendly choices, these are not actively sought as part of the template.

Another major gap is that the NECPs are for a ten-year period, whilst the LTS looks to the 2050 horizon. Whilst it is true that the template often asks for targets or projections up to the 2040 horizon and sometimes the 2050 horizon, this is not systematic.

As a means of filling this gap, the Governance Regulation does specify that the NECPs must be consistent with national Long-Term Strategies. These are separate national-level documents to be prepared by Member States that detail

[78] Regulation (EU) 2018/1999, Annex I Section A 3.2.iv.
[79] COM(2018) 773, p. 6.

climate and energy policy for the following 30-year period, and must be submitted to the European Commission by January 2020. A template for national long-term strategies is set out in Annex IV of the Governance Regulation[80]. The template requires Member States to detail projections and targets to 2050, as well as descriptions of the expected means of reaching these projections. The template demands considerably less detail than the NECPs, but does include space for Member States to describe drivers for changes on the demand side and in energy consumption, as well as socio-economic impacts. The national long-term strategies should be consistent with the NECPs and contribute to fulfilling the Paris Agreement objective of keeping global warming since industrialisation to well below 2°C and making efforts to keep it below 1.5°C.

3.3 Role of local and regional authorities

The LTS highlights the role of LRAs, although the focus is somewhat limited to consumer lifestyle changes and urban spatial planning. The Governance Regulation provides for some consultation of LRAs through the multilevel climate and energy dialogue forum that Member States are obliged to set up. Local authorities are specifically identified as one institution that should take part in these dialogues.

However, the extent and quality of the multilevel dialogues are uncertain and depend on the individual Member States. The PlanUp project, an EU LIFE-funded project that will support participation of non-State actors in the NECPs, should reinforce participation of LRAs in the five Member States where it is being run. It will offer a model for other Member States when they are consulting on future drafts of the NECPs. The project rates countries on their inclusion effort at engaging in multilevel dialogue.

As national-level documents the NECPs do not focus on specific regional or local actions or climate plans (e.g. those prepared in the context of Covenant of Mayors). Without any specific requirements what additional information the NECPs can cover, it would be at the discretion of Member States to decide whether any links to regional or local climate and energy initiatives are established and included in the NECPs.

[80] Regulation (EU) 2018/1999, Article 15.

4. Part 4: Latest development of the Paris Agreement (Rulebook) and the EU Long Term Strategy

The EU is viewed as one of the main actors in international climate policy, due to both its large share of the global GHG emissions and also for its current leading role in international efforts on climate action. With the ambitions set out in the framework of the 2030 climate and energy framework and the LTS, the EU signals its commitment to increased global ambition levels, in line with achieving net zero emissions in 2050. This section explores the links between the latest developments in international climate negotiations in the COP process – specifically, the outcomes of COP24 held in December 2018 in Katowice – and the LTS.

4.1 COP24 outcomes and the Paris Rulebook

COP24 served as the first official meeting of the Parties of the Paris Agreement and concluded with an agreement of a Paris Agreement Work Programme (PAWP) or a 'Rulebook'[81]. The Rulebook is the main outcome of the Conference and contributes to the implementation of the Paris Agreement[82], while a series of other decisions that outline further details support it.

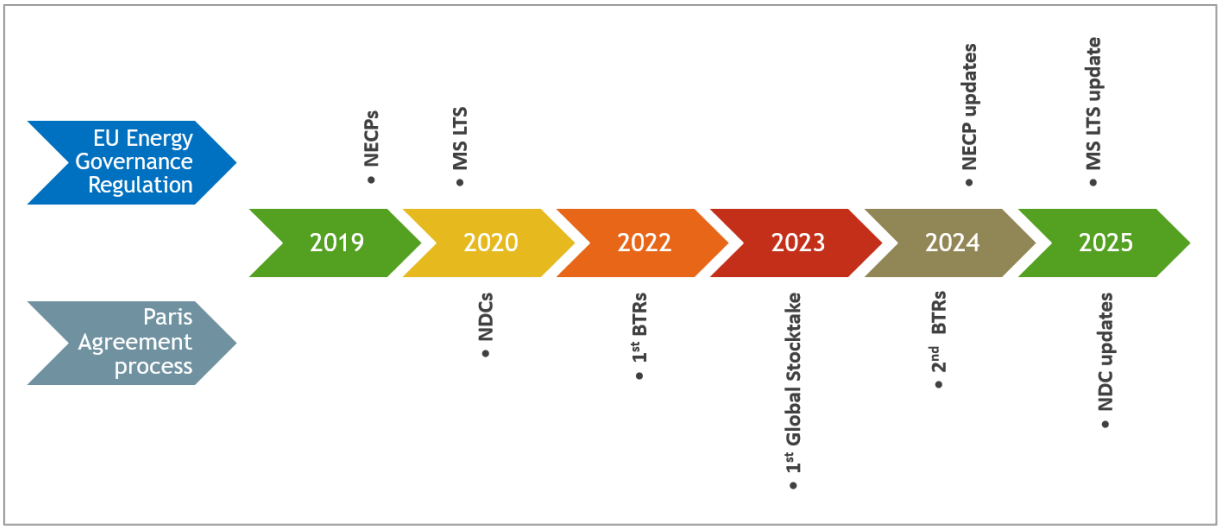
4.1.1 The Paris Rulebook and COP24

The main purpose of the Rulebook is to ensure the information reported by the Parties is clear and comparable, which is paramount for one of the cornerstones of the Paris Agreement: transparency. The agreed transparency framework sets out guidance and elements all Parties should consider when reporting and communicating their efforts and progress on climate action. While it grants flexibility to developing countries on the scope of their reporting, it also requires that whenever this flexibility is used, they '*shall clearly indicate the provision to which flexibility is applied, concisely clarify capacity constraints […], and provide self-determined estimated time frames for improvements in relation to those capacity constraints*'[83].

[81] UNFCCC, PAWP website.
[82] UNFCCC, 2018, Decision 1/CP.24: Preparations for the implementation of the Paris Agreement and the first session of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement.
[83] UNFCCC, 2018, Draft decision -/CMA.1: Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement.

More concretely, the Rulebook develops the modalities, procedures and guidelines for the implementation of the transparency framework for action and support (Article 13 of the Paris Agreement), which will replace the current measurement, reporting and verification system for emissions sources and sinks established by the Kyoto Protocol and the Biennial Reports required under the UNFCCC. The first Transparency Report is scheduled for 2022, requiring biennial updates from then onwards (so called Biennial Transparency Reports - BTRs). These updates should go beyond measuring and reporting emissions progress and should include information about activities to reduce emissions from deforestation and forest degradation[84] and as well as chapters on research, education, and public awareness. The following figure provides a schematic overview of the key reporting deadlines under the Governance Regulation and the Paris Agreement Rulebook.

Figure 2: Key deadlines related to the Governance Regulation and the Paris Agreement Rulebook



Source: Own analysis.
Note: MS LTS refers to the Member States' national long-term strategies required under Article 15 of the GR.

In addition to the transparency framework, the Rulebook also covers aspects related to the global stocktake process, (Article 14 of the Paris Agreement). Parties are expected to undertake and communicate ambitious efforts with a view to hold the global temperature increase 'well below 2°C' starting by sharing their first NDCs by 2020[85] with subsequent updates every five years thereafter[86]. The main features of the NDCs are summarised in Box 3. Following the submission of the first Transparency Reports in 2022, the first global stocktake is expected in 2023. It will be undertaken every five years thereafter

[84] This relates to activities in the context of the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (also known as REDD+).
[85] Parties submitted their first Intended NDCs in 2015-16.
[86] Article 4(9) of the Paris Agreement.

with the purpose to periodically assess the collective progress towards achieving the objectives of the Paris Agreement[87]. The Rulebook provides further clarity about the process for carrying out the global stocktake.

Box 3: Main features of the NDCs

Timing: submission of Intended NDCs by COP21 (2015), submission of NDCs in 2020 and updates every five years thereafter (e.g. 2025, 2030).

Content: Article 4 of the Agreement requires Parties to prepare, communicate and maintain NDCs that pursue domestic mitigation measures, progressing with each successive NDC submitted and reflecting the highest possible ambition. Developed countries should continue taking the lead by undertaking economy-wide absolute emission reduction targets. Developing countries should continue enhancing their mitigation efforts and are encouraged to move over time towards economy-wide emission reduction or limitation targets in the light of different national circumstances. Mitigation co-benefits from adaptation and/or economic diversification plans can contribute to mitigation outcomes.

Accounting: According to Article 4(13) of the Paris Agreement, accounting of anthropogenic emissions and removals should be transparent, consistent and accurate, ensuring the avoidance of double counting or emissions or removals by different parties. To support consistent accounting and reporting of information in NDCs, COP24 adopted guidance on 'information to facilitate clarity, transparency and understanding of nationally determined contributions' (ICTU)[88].

The Rulebook and other supporting decisions adopted at COP24 provide details also about climate finance. Details are outlined about different United Nations funds that will be used to address barriers faced by developing countries concerning climate finance with the goal of improving the predictability of financial flows. In order to secure concrete steps on climate finance and capacity-building, the COP called for a clear financial roadmap towards reaching an annual mobilisation of USD 100 billion for mitigation and adaptation in developing countries. Moreover, it was agreed that deliberations on the post-2025 global climate finance goal will start in 2020[89].

Other topics discussed at COP24 included the reception of the IPCC 1.5 Report and the social cost of the transition towards a low-carbon economy. Parties acknowledged the valuable scientific input of the IPCC 1.5 Report and its guidance on how to strengthen the global response to climate change in the context of sustainable development. Regarding the social cost of the transition to a low-carbon economy, Poland presented the 'Just Transition Declaration' (or Silesia Declaration) whose main points are summarised in Box 4.

[87] Article 14 of the Paris Agreement.
[88] UNFCCC, 2018, Draft decision -/CMA.1: Further guidance in relation to the mitigation section of decision 1/CP.21.
[89] IISD, 2018, Earth Negotiations Bulletin (ENB), Summary of the Katowice Climate Change Conference.

Box 4: The Just Transition Declaration (or Silesia Declaration)[90]

The Silesia Declaration stresses the need to consider the social dimension of the transition to low-GHG economies, in line with the International Labour Organisation's[91] and the United Nations's[92] calls for addressing environmental, social and economic issues in an integrated manner. This Declaration particularly focuses on the transition from fossil fuel intensive economies to low-GHG ones, considering the potential high social impact it may have on coal-intensive regions like Silesia (Poland), where COP24 took place.

While the document does not provide any agenda nor action points, its content can be summarised in the following recommendations:

- Ensure a just transition of the workforce by creating quality jobs - this is crucial to ensure an effective transition to low-GHG development.
- Develop of climate-resilient infrastructure.
- Underline employment opportunities of the transition to low-GHG economy.
- Recognise the challenges faced by sectors, cities and regions heavily relying on fossil fuels and high emitting industries, ensuring a decent future for their workers.
- Involve all social partners and consider the just transition of the workforce when developing NDCs, long-term strategies and adaptation plans.
- Share experiences from Parties and stakeholders on supporting workers and regions in the transition to a low-GHG economy.
- Support developing countries to promote low-GHG economies, also in non-urban areas.

4.1.2 Gaps and outstanding issues after COP24

COP24 generated high expectations as it was also the First Meeting of the Parties to the Paris Agreement. The focus on operationalising the Paris Agreement was seen as a test of the Agreement's feasibility. In addition, the publication of the IPCC Special Report, including its alarming 12-year timeframe until the 'point of no return', only two months before the summit led to calls for the Parties to urgently step-up mitigation efforts. Whether the world could build a solid roadmap and implementation framework for achieving the Agreements' goal of limiting temperature increase to 1.5^{o}C was a key question to be answered in this summit, and its outcome only partially met the expectations.

Progress was made on some of the Rulebook's elements: notably agreement was reached on procedures for the global stocktake process, reporting of NDCs and sensitive issues such as the reporting requirements for tracking progress (i.e. the transparency framework), including agreement on some flexibility for LDCs and SIDS, and climate finance[93]. However, the final deal failed to make relevant progress on two key features that could have enhanced the ambition and flexibility of the global climate action efforts: voluntary market mechanisms and a global stocktake system.

[90] COP24, 2018, Just Transition Declaration.
[91] ILO, 2016, Guidelines for a just transition towards environmentally friendly sustainable economies and societies for all.
[92] United Nations, SDGs website.
[93] Florence School of Regulation, 2019, Seminar: Highlights from Katowice – COP24, 12 February 2019.

Cooperative approaches and voluntary market mechanisms are set out in Article 6 of the Paris Agreement, and allow for offsetting carbon emissions in one country through emissions reductions in the country of another Party. These mechanisms are similar to the flexibility mechanisms under the Kyoto Protocol (i.e. the Clean Development Mechanism and Joint Implementation Mechanism) and aim to add flexibility to emission reduction efforts and provide an incentive to increase the ambition of NDCs. The Parties could not agree on a clear mechanism to ensure that emission reductions generated in one place would not be counted twice in the global stocktake. This section of the Rulebook was postponed to next COP meeting in December 2019[94].

The summit did not serve to raise the global ambition level either, although the Parties managed to set some ground rules for the functioning of the global stocktake system. The global stocktake aims to regularly assess the Parties' NDCs and their potential to meet the climate objectives of the Paris Agreement and it is considered to be a key component of the Agreement's 'ambition mechanism'. While these rules are to be put into practice by 2023, during the first stocktaking exercise, the key question of how this ambition level will be raised to limit global warming to less than 1.5°C is still unknown; current commitments under the Paris Agreement are estimated to lead to a global temperature increase of around 3°C[95]. High-level negotiations on a general raise of ambition levels was postponed until the United Nations Climate Summit in September 2019. Information about upcoming international meetings relevant for the Paris Agreement negotiations can be found in Annex 3.

4.2 Consistency of the Rulebook with the LTS

While both, the Paris Rulebook and the EU's LTS set the framework of supranational efforts to tackle climate change, they do it from very different perspectives. This section aims at highlighting how elements from these two documents may interact, considering the potential impacts and opportunities for the EU arising from the decisions adopted at COP24.

4.2.1 The EU and COP24 outcomes

A key part of the Paris Rulebook concerns the rules for reporting and transparency, which is likely to have implications for the EU and the way it reports its ambitions and progress on its NDC. At the moment the EU is reporting emissions under the measurement, reporting and verification system in

[94] UNFCCC, 2018, Decision -/CMA.1: Matters relating to Article 6 of the Paris Agreement.
[95] UNEP, 2018, Emissions Gap Report 2018.

the context of the Kyoto Protocol and overall progress on climate policy in the Biennial Reports under the UNFCCC. It also submitted an intended NDC before the adoption of the Paris Agreement (see Box 5). The implementation of the Paris Rulebook will, therefore, require an update of the procedures and existing legislation that govern this process within the EU. Nevertheless, the timetables under the current system and the Paris Rulebook are comparable as both require reporting the progress of emission reductions every two years (currently with the Biennial Reports and in the future with the BTRs).

Box 5: The EU's intended NDC

The EU submitted a single Intended NDC[96] in 2015 for all the Member States, in which committed to a binding target of at least 40% domestic reduction in GHG emissions by 2030 compared to 1990. The EU's Intended NDCs itself is a five-page document that presents a brief overview of the target's coverage and some assumptions. It does not detail how the emission reduction target will be achieved, but links its planning process to the Climate and Energy Framework and it planned update under the Clean Energy package. The sectors covered by the EU's Intended NDC include energy, industry, agriculture, waste and LULUCF, however, reductions from international credits (market-based mechanism) were excluded.

Concerning the accounting and reporting of climate action ambitions and efforts, which Parties need to communicate with their NDCs, the provisions of the Governance Regulation are likely to facilitate this. Under this Regulation, Member States are required to submit their finalised NECPs by the end of 2019 and to develop national long-term strategies by 1 January 2020, whose consistency with the NECPs and contribution to the objectives of the Paris Agreement must be ensured (see Part 3 for details). These requirements will undoubtedly support the EU's reporting under the new Paris Agreement Rulebook according to which NDCs are to be submitted by 2020. The submission of the NECPs by the end of 2019 will allow the EU to review the most up-to-date information about the Member States ambitions and efforts and, if necessary, make any adjustments to its updated NDC that will be submitted in 2020. Given that the reporting timeframes for the NDCs and the NECPs and their subsequent updates under both frameworks are operate in parallel (see Figure 2), it is to be expected that the NECPs will inform and be consistent with the NDCs.

Furthermore, as the EU requests its Member States to develop integrated NECPs and has already published a LTS with a post-2030 horizon, the EU is substantially ahead of most other Parties to the Paris Agreement. It is particularly advanced when it comes to solid planning tools that can back up the EU's and its Member States' commitments and ambitions for reducing emissions. These and other elements comprised in the agreed transparency framework of the Rulebook, including the broadened scope of the expected

[96] UNFCCC, NDC Registry website.

updates that the Parties must submit (e.g. education and public awareness), are already considered and detailed within the EU reporting schemes on climate change, particularly in the NECPs (see Table 3) within the 2030 climate and energy framework. Therefore, information required by the transparency framework of the new Paris Rulebook will be available both at national and EU levels within the 2030 climate and energy framework.

Concerning ambition, the EU aims for climate neutrality by 2050, which is in line with the objectives of the Paris Agreement. However, as indicated by the IPCC 1.5 Report, current commitments of all Parties under the Paris Agreement are insufficient to meet the objectives of the Agreement. Even if the EU is successful in implementing its LTS and reaching net zero emissions, there is a risk that catastrophic climate change is still a real possibility and ambitious efforts will be required by other Parties too.

On another aspect covered by COP24 - climate finance, the EU is already the biggest contributor of public climate finance to developing countries and has contributed more than EUR 75 billion so far[97].

4.2.2 The LTS and COP24 outcomes

While the COP24 did not radically increase the ambition in the international climate framework, it did make concrete progress in operationalising the Paris Agreement, ultimately supporting the effectiveness of the Agreement in reducing emissions and potentially more ambitious commitments in the future. While other Parties such as the US did not officially recognise the findings of the report, the EU reaffirmed that it would strive to meet the IPCC's recommendations on limiting global temperature increase to no more than 1.5^{o}C with the aim of reducing its potential disastrous effects[98]. This commitment is reflected by the LTS, which was published immediately before COP24.

Direct comparisons between the COP24 outcomes in terms of the Paris Rulebook and the LTS are difficult as they are very different documents in terms of scope and purpose. However, the LTS sends a signal to other Parties on the EU's climate objectives. The LTS looks beyond the 2030 horizon of the current EU NDC and explores the options for achieving climate neutrality by 2050, which is in line with the IPCC's findings[99].

[97] DG CLIMA, International Climate Finance website.
[98] European Commission, 2018, Commissioners Miguel Arias Cañete and Carlos Moedas welcome the UN climate change report on 1.5° C global warming limit.
[99] IPCC, 2018, Summary for Policymakers of IPCC Special Report on Global Warming of 1.5°C approved by governments.

The LTS and its scenarios are focused on decarbonisation and climate neutrality pathways based on existing technological options and do not consider international carbon markets or voluntary market mechanisms as part of the mitigation options. Further clarity on these options from this and future COPs might provide additional opportunities for reducing emissions, especially in sectors or Member States which may struggle to reach climate neutrality by 2050. The flexibility granted by the international framework on climate efforts will create room for a higher diversity of strategies on climate change.

4.3 Potential role of LRAs in the COP process

As currently designed, the COP process focuses on gathering state Parties to the UNFCCC and invites non-state actors such as LRAs or civil society as observers. Many of the climate policies such as strategies on sustainable transport, waste or circular economy are, according to the UNFCCC[100], crucial for achieving the Paris goals. These policies ultimately rely on LRAs for their effective implementation since cities account for 70% of world emissions and local governments are responsible for implementing more than 70% of emission reduction measures and 90% of climate adaptation actions[101].

In order to facilitate a dialogue among Parties in 2018 for taking stock of the collective efforts and progress towards the goals of the Paris Agreement and support the preparation of the NDCs, the Talanoa Dialogue was launched at COP23 as a platform for inclusive and participatory sharing of ideas. This inspired the launch of the 'Cities and Regions Talanoa Dialogues' that aim to gather LRAs, national authorities, NGOs and other stakeholders to collectively provide input for the NDCs. By bringing all levels of government and climate stakeholders together these dialogues aim to co-design and co-implement climate policy that ultimately raising climate ambition at all levels of governance[102].

In addition, at COP23 the CoR, together with other LRAs, called for a formal and active role of LRAs in the COP process by the development of Regionally and Locally Determined Contributions (RLDCs). The RLDCs are infra-national emission reduction targets that would aim at bridging the gap between the NDCs and the emission reductions required to achieve the objectives of the Paris Agreement. While the RLDCs feature in the final COP23 declaration[103], these

[100] UNFCCC, 2018, Circular Economy Is Crucial to Paris Goals – Study.
[101] Committee of the Regions, 2018, COP24: cities and regions call for a formal role in the Paris Agreement.
[102] ICLEI, Cities and Regions Talanoa Dialogues website.
[103] European Alliance, 2017, Major success for CoR and EA group as locally and regionally determined contributions get featured in the COP 23 final declaration.

have not been formally integrated in COP24 and the Paris Rulebook, leaving LRA participation to integration in national climate strategies or through formal consultation processes such as the Talanoa Dialogues.

The current role of LRAs in the COP process is, therefore, limited to providing information and consulting on the development of NDCs through the Talanoa Dialogues. If given a more formal role, these authorities could become an important part on the negotiations by stepping up the ambition of climate strategies, following a similar path as several US States and cities did when their country decided to withdraw from the Paris Agreement[104]. Moreover, LRAs can support national efforts by providing additional and complementary climate finance for the financial instruments of the UNFCCC and the Paris Agreement[105]. At this point, the RLDCs could become both a tool for improving the ambition level, but also an opportunity to test different strategies and solutions before their national implementation, allowing to improve the efficiency of the transition towards a low-emission economy.

Given the size and the relatively low political profile of LRAs in comparison with their national authorities, their individual actions may not have a large impact on the global account of GHG emissions, however, when put together, the contributions of regions and cities have a tremendous capacity to raise the ambition of climate action efforts. LRAs are also much more flexible than national or supranational governments when it comes to putting into practice initiatives and strategies and can thus offer valuable experiences and lessons for replication more rapidly. The urgency to act, as signalled by the IPCC 1.5 Report, makes raising the profile of LRAs at COP negotiations more necessary than ever given their capacity to implement ambitious strategies in a broad diversity of sectors in much shorter term than national authorities.

In this scenario, the RLDCs may be the decisive tool that allows a similar effort-comparison exercise in addition to the already existing one at national level with the NDCs. Considering the outcomes of COP24 and how the global stocktaking exercise, as the core ambition mechanism of the Paris Agreement, is being delayed and the difficulty to reach real ground-breaking agreements at national level, these RLDCs could become the key to reduce emissions at a sufficiently fast pace to achieve the objectives of the Paris Agreement.

[104] United States Climate Alliance website.
[105] Florence School of Regulation, 2019, Seminar: Highlights from Katowice – COP24, 12 February 2019.

5. Part 5: Conclusions and recommendations

The analysis in the previous parts of this report highlight the ambitious vision the EU has put forward for reaching the climate goals of the Paris Agreement. While long-term objectives and options are being explored, the Governance Regulation and the 2030 climate and energy framework outline concrete actions and targets for the short-term. However, the success of this ambitious vision will depend on: on the one hand, a coherent EU policy framework at all levels of governance that can enable and support the transition to climate neutrality; and on the other hand, matching ambitions and efforts at the global level that ensure the Paris objectives are pursued by all Parties of the Agreement and the UNFCCC. At the same time, a transition to a climate neutral economy will have overarching impacts that might vary across regions and countries and which will require careful management. In light of these conclusions, the rest of Part 5 outlines recommendations for EU, national and local policy-makers.

5.1 EU and national policy-makers

5.1.1 Ensure the various impacts of the LTS are well understood

While the LTS and its In-Depth Analysis provide a lot of useful information and assessment of various sectoral changes that might take place, the analysis of all possible impacts of the LTS scenarios remains high-level and focused on EU-wide effects. Better understanding of the environmental impacts and economic impacts beyond investment needs as well as the regional differences and distributional impacts will be required for the design of successful policies. Furthermore, adaptation will be another important aspect of future climate policy and the links, both in terms of trade-offs and synergies, between the long-term scenarios and adaptive measures should be examined further. Therefore, efforts should be directed at studying the impacts of the LTS and the links between mitigation and adaptation actions in more details.

5.1.2 Put in place a policy framework that can implement the LTS

At the EU level, reaching climate neutrality by 2050 will require a combination of actions and options. Current efforts and the achievement of the 2030 climate and energy targets are expected to result in 45% decrease of the EU's GHG emissions. A review of the 2030 emission reduction target in line with the LTS could ensure efforts are on a feasible pathway towards climate neutrality by 2050 and might also generate momentum at the international level for pursuing actions that will deliver the objectives of the Paris Agreement. As highlighted by

the most ambitious LTS scenarios, climate neutrality by 2050 is possible only through a variety of technologies and demand-side measures rather than through a single pathway and the policy framework should reflect this accordingly. Therefore, future EU policy should ensure all possible drivers and alternatives are supported ensuring lock-in or avoidance on a single technology or pathway is avoided. At the same time, policies should ensure all necessary enabling conditions, including climate finance, are in place. Policies at the national level should support EU efforts and go beyond when possible. The NECPs provide an opportunity to outline comprehensive plans that link decarbonisation and energy sector objectives with other aspects of the climate neutrality transition highlighted by the LTS e.g. mobility and transport, circular economy and demand-side measures.

5.1.3 Involve all levels of governance in the decision-making process

The transition to climate neutrality will have varying impacts across regions, which may be further aggravated by the impacts of climate change that are highly variable by geography. Hence, each community and region might have different needs, opportunities and risks to manage. Ensuring the transition is socially just will require a balancing risks and opportunities across highly diverse local and regional contexts. Therefore, LRAs, as representatives of communities and their needs, should be consulted and involved as much as possible in the decision-making process concerning the EU transition to climate neutrality. In this context, the possibilities to use the NECPs as planning documents that cover also local or sub-national initiatives can be explored and findings from projects such as PlanUp can be used to provide insights in this regard.

5.2 Local and regional policy-makers

5.2.1 Support EU and national policies for implementation of the LTS

As explored in Part 2 of this report, LRAs have various tools at their disposal that can support EU and national efforts to decarbonise the economy and achieve climate neutrality. Therefore, LRAs should adopt measures that support the different drivers, both technological and demand-side ones, and horizontal enabling conditions necessary to realise the LTS scenarios. This includes, but is not limited to, using their responsibilities to oversee territorial and urban planning, manage mobility, regulate the local economy, finance local projects, lead by example and raise awareness in order to:

- Improve the energy efficiency of the local building stock and construct new nearly zero emission buildings;
- Develop renewable energy projects and promote the uptake of RES by local citizens and business, including through the promotion of presumption and local energy communities;
- Put in place systems and measures that stimulate non-fossil or low-carbon mobility options and transport networks;
- Support the circular economy both through waste management at the local level and initiatives that can inspire local citizens and businesses to take action;
- Develop the local infrastructure so that in can support future low-carbon technologies such as electrification, use of alternative energy carriers, use of RES, CCS or CCU;
- Support the transformation of local industries.

5.2.2 Explore various financing options to meet the investment needs of the LTS

Putting in place the enabling conditions and drivers that can achieve the LTS and its objectives will require substantial resources, especially when it comes to developing the necessary infrastructure. Investment will be required at all levels of governance and LRAs are in a unique position to finance projects that particularly beneficial for their regions or areas. Therefore, LRAs should explore all possible avenues for securing climate finance and making the necessary investments. While there can be obstacles and challenges to accessing all possible finance, especially from private sources, there are various EU instruments that can be used as a first step, including the European Structural and Investment Funds, Horizon Europe, Invest Europe, LIFE and financing instruments managed by the European Investment Bank.

5.2.3 Manage risks and opportunities at the local level

The transition to climate neutrality envisioned in the LTS and its scenarios will have varying impacts that will create both new opportunities and risks across regions and communities in the EU. LRAs will be at the frontline of these changes and will have a responsibility to manage both the risks and opportunities that arise, especially if a just transition is to be ensured. Therefore, LRAs will require a good understanding of the likely impacts of different scenarios and changes in their regions and areas and should explore the most suitable solutions at their disposal. While the magnitudes of specific impacts might vary and would require careful examination, there are some relatively certain changes that can be expected and LRAs can start adopting relevant

policies for managing those. These changes include both opportunities and risks such as:

- Deployment of RES – The trend of growing RE share is likely to continue offering a new opportunity for economic development. Hence, LRAs can explore the unique features of their territories that can provide them with a competitive advantage and develop RES that are specific in their areas e.g. biomass can be developed in rural communities, offshore wind and novel ocean or tidal energy can be deployed by coastal communities, solar energy can be developed in South European communities.

- Improving energy efficiency – Energy poverty is a challenge in many regions and improving the energy efficiency of the building stock can not only improve the carbon performance of the sector but might also help tackle a serious social issue such as energy poverty.

- Transformation of industries - Traditional industries are already facing various global trends that transform them, including globalisation, digitalisation and automation, while mining and extraction industries are expected to decline as a result of decarbonisation efforts. This can result in a decline of certain sector and even unemployment, especially in regions highly specialised in those sectors, but also in new opportunities for economic development. Therefore, LRAs should take measures that can support local businesses and workforce in handling these challenges and taking advantage of arising opportunities. This might include measures that support the workforce (e.g. training to upskill or reskill workers), measures that support the industry (e.g. policies for promoting new business or industry, local tax policies) or even measures that would help manage a transformed local economy (e.g. policies for management of stranded assets and repurposed use of infrastructure).

5.2.4 Support participatory decision-making and engagement with local stakeholders

The participation of different stakeholders in the preparation of policies or their implementation can create a sense of ownership and provide more legitimacy to the policy. Furthermore, the success of environmental and climate actions depends greatly on local support and stakeholder acceptance. LRAs have an important role to play in supporting participatory decision-making and engaging citizens and local stakeholders. LRAs can put in place mechanisms that facilitate participation (e.g. through concepts such as CLLD or co-creation) allowing local stakeholders not only to learn about local policies that might support the LTS but also to contribute to the development of working solutions for the local

needs. This can support the overall implementation of policies for climate neutrality and might increase the awareness of local stakeholders triggering the uptake of demand-side actions.

Annex 1: List of references

All weblinks listed below were functional as of 8 March 2019.

EU policy documents and European Commission sources:

Decision No 1386/2013/EU […] on a General Union Environment Action Programme to 2020 'Living well, within the limits of our planet'.

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DG ENER, Commission proposes new rules for consumer centred clean energy transition website: https://ec.europa.eu/energy/en/news/commission-proposes-new-rules-consumer-centred-clean-energy-transition

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Annex 2: Additional information about the LTS scenarios

Emission reduction options per sector

The emission reduction options considered in the different sectors according to LTS In-depth Analysis [106] are presented below. The LTS In-depth Analysis does not specify to what extent these options are ready for deployment or have already been implemented.

Energy sector:

- Development of RES, particularly those that are well known today: wind, solar (solar thermal and photovoltaic), geothermal, tide, wave and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases;
- Use of CCS, CCU and BECCS technologies;
- Use of alternative energy carriers where fossil fuels are hard to replace, including hydrogen (H_2), e-gas (e-CH_4) and e-liquids;
- Reinforcing and making electricity networks smarter in order to accommodate the penetration of RES;
- Developing the sector coupling (i.e. linking energy, transport and industrial infrastructure) in order to increase RES penetration and energy storage.

Buildings:

- Improving the energy performance of the building shell, especially through targeted renovation of the existing buildings stock in the EU;
- Use of energy efficient equipment (for heating and cooling, water heating and cooking) and appliances;
- Switching to RES for heating and cooling;
- Deployment of smart technologies in buildings in order to optimize their operation, the use of RES and demand-side management;
- Construction of nearly zero energy buildings;
- Uptake of behavioural changes in societal and consumer choices e.g. in heating patterns, sharing of spaces and appliances and urban planning.

[106] LTS In-depth Analysis, Section 4.

Transport sector:

- Improving vehicle efficiency (e.g. engine efficiency, aerodynamics) to facilitate the uptake of low- and zero emission vehicles;
- Electrification and development of batteries and fuel cells;
- Development of the transport infrastructure (e.g. recharging stations) to accommodate the use of battery electric vehicles;
- Use of alternative carbon-neutral fuels where electrification or zero emission vehicles are not possible, including advanced biofuels and biomethane, e-fuels;
- Realising the potential of multimodal transport and modal shifts;
- Uptake of behavioural changes in societal and consumer choices e.g. implementation of the 'polluter pays' principle, urban planning and provision of public transport and multimodal options, uptake of digitalization by businesses as an alternative to business travel.

Industry:

- Improving the energy efficiency of processes;
- Replacing fossil fuels with electrification or alternative fuels where possible, including biofuels, hydrogen and e-fuels;
- Developing innovative low-carbon processes that use alternative chemical processes for material production;
- Use of CCS and CCU;
- Improving resource efficiency and reducing the demand for raw materials, including through recycling and circular economy;
- Developing material substitution to replace high-carbon inputs with alternatives;
- Developing industrial symbiosis between closely located sites in order to facilitate the exchange of materials and resources.

Agriculture (non-CO_2 GHG emissions, primarily CH_4 and N_2O):

- Increasing productivity;
- Adopting innovative technologies and practices that target the main emissions sources, including targeting enteric fermentation, anaerobic digestion, precision farming to control the application of fertilizers, nitrification inhibitors;
- Changing consumer preferences primarily e.g. to reduce the consumption of red meat and the packaging waste from the food sector.

Other sectors (non-CO_2 GHG emissions):

- Fugitive emissions from the energy sector (e.g. coal mining, oil and gas production, gas distribution, fuel combustion) - these emissions can be controlled through a combination of decreased fuel consumption and increased application of technological mitigation options.
- Emissions related to waste (primarily methane emissions related to solid waste, wastewaters) – although the current legislation is expected to halve the methane emissions by 2050 (compared to 2005), there is additional technical potential to reduce the emissions further.
- F-gases from air conditioning, refrigeration and industry – although the current F-gas legislation has significantly reduced emissions, there is additional technical potential to decrease these emissions further thanks to improvements in refrigeration and air conditioning.

Land sources and LULUCF emissions:

- Slowing down soil degradation and enhancing the carbon sequestration of soils;
- Protecting and limiting the use of organic soils and peatlands for agriculture;
- Using sustainable soil management practices (e.g. planting of catch crops);
- Afforestation, reforestation and reduced deforestation.

Environmental impacts

The environmental impacts of the LTS scenarios are likely to vary, at least to an extent, depending on the technologies and other emission reduction options chosen in the different sectors as summarized in the following table.

Table 4: Impacts on key environmental areas by scenario

Scenario	Air quality	Nature and biodiversity	Resource use
All scenarios	Positive: The reduction of GHG emissions, replacement of fossil fuels in all sectors and the modal shifts in the transport sector will reduce the emissions of air pollutants from combustion.	Mixed: The growth of RES, specifically biomass, in the energy mix and the remaining share of nuclear energy might pose risks. However, there will be benefits from the improvement of air quality and the reduction of GHG emissions.	Mixed: The growth of RES, specifically biomass, in the energy mix and the remaining share of nuclear energy might put pressure on water resources and raw materials. However, actions towards more efficiency may balance those risks.
ELEC	Benefits might be higher thanks especially to electrification of the transport sector.	Risks might be higher due to the large share of RES (esp. biomass) for power generation.	Risks might be higher due to the large share of RES (esp. biomass) for power generation.
H2	Impacts are expected to be moderate.	Impacts will depend on the production process of	Impacts will depend on the production process of

Scenario	Air quality	Nature and biodiversity	Resource use
		H2.	H2.
P2X	Impacts are expected to be moderate.	Impacts will depend on the production process of e-fuels.	Impacts will depend on the production process of e-fuels.
EE	Benefits might be higher thanks to reducing energy demand in all sectors.	Risks might be lower thanks to a lower energy demand.	Risks might be lower thanks to a lower energy demand.
CIRC	Benefits might be higher thanks to reducing energy demand in all sectors, especially industry.	Risks might be lower thanks to a lower energy demand.	Risks might be lower thanks to a lower energy demand.
COMBO	Impacts are expected to be moderate.	Impacts will depend on the specific technological options chosen.	Impacts will depend on the specific technological options chosen.
1.5 TECH	Benefits might be higher as electrification will be supported by negative emissions.	Risks might be higher as BECCS is expected to play a significant role in this scenario.	Risks might be higher due to the development of BECCS, CCS/CCU technologies.
1.5 LIFE	Benefits might be higher thanks to reducing energy demand in all sectors.	Risks might be lower thanks to a lower energy demand.	Risks might be lower thanks to a lower demand for energy, other production inputs and finished products.

Source: Own analysis, see section 2.2.

Economic impacts

The estimated investment needs differ according to the ambition and options considered in each scenario and in all LTS scenarios will require additional investments compared to those in the baseline as summarized in the following table.

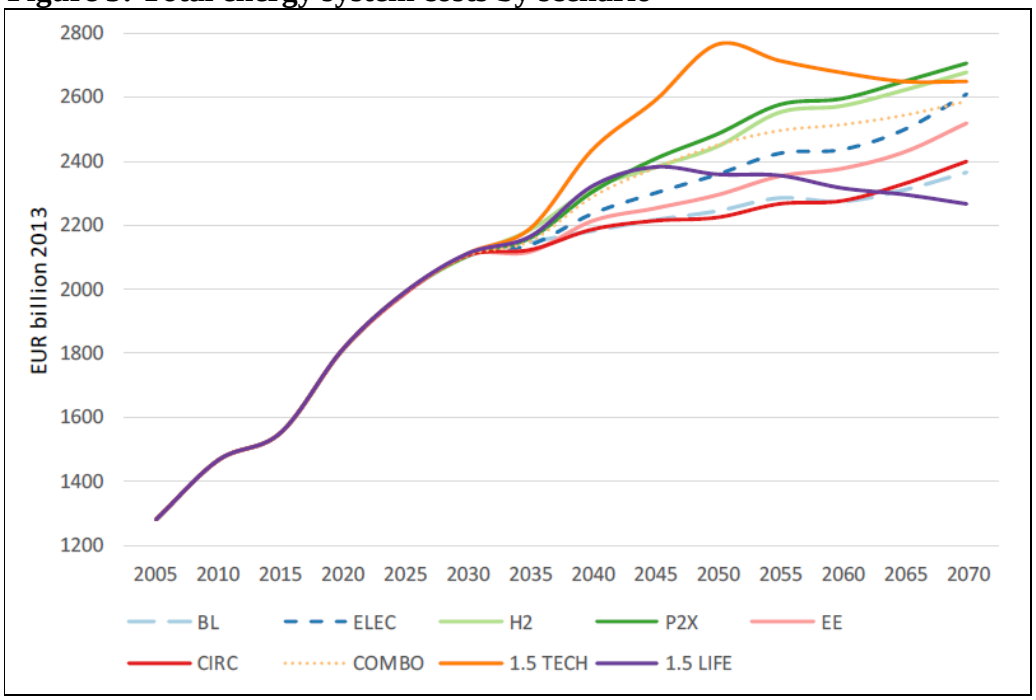
Table 5: Additional average annual investment, compared to the investment needs in the baseline, by scenario for the period 2031-2050 (billion EUR 2013)

Sector	EE	CIRC	ELEC	H2	P2X	COMBO	1.5 TECH	1.5 LIFE
Power grid	9.3	19.7	39.0	19.7	24.0	28.1	31.4	18.9
Power plants	10.3	20.1	36.6	46.5	67.7	53.4	80.2	53.7
Boilers	-0.2	0.5	0.6	-0.4	-0.8	-0.7	-0.5	-0.7
New carriers	0.6	0.6	0.7	5.2	28.6	16.0	21.6	16.2
Total: Energy – supply side	**20**	**41**	**77**	**71**	**120**	**97**	**133**	**88**
Industry	24.5	2.1	2.5	2.1	2.7	15.2	17.0	11.2
Residential	35.8	12.2	15.0	-0.5	-1.3	18.9	26.6	28.3
Tertiary	10.1	6.6	3.3	4.3	5.8	13.4	22.3	14.1
Total: Energy – demand side	**70**	**21**	**21**	**6**	**7**	**48**	**66**	**54**
Transport	**44**	**24**	**68**	**94**	**30**	**68**	**91**	**34**
TOTAL	**135**	**86**	**166**	**171**	**157**	**212**	**290**	**176**

Source: European Commission, 2018, In-Depth Analysis in Support of the Commission Communication COM(2018) 773: A Clean Planet for all, A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy, Section 4, Table 11, p. 204.
Note: The orange and blue colours were added to show the highest and lowest additional annual investment needed respectively.

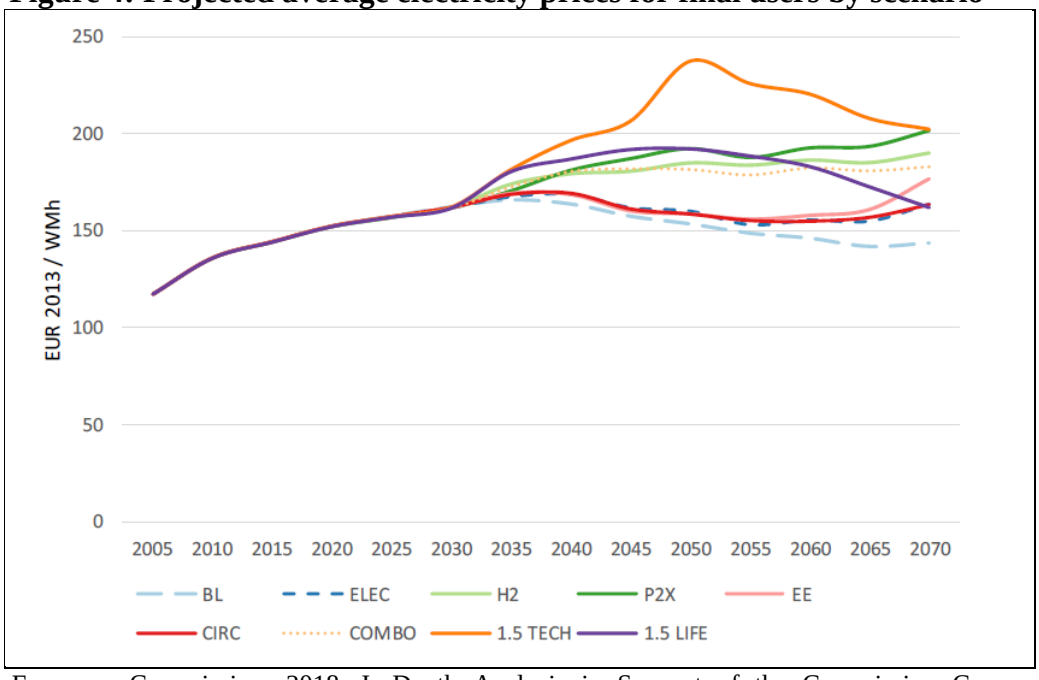
In the energy sector, system costs and electricity prices will increase by 2030 across all scenarios before they start varying by pathways as shown in the following figures.

Figure 3: Total energy system costs by scenario



Source: European Commission, 2018, In-Depth Analysis in Support of the Commission Communication COM(2018) 773: A Clean Planet for all, A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy, Section 4, p.208.

Figure 4: Projected average electricity prices for final users by scenario



Source: European Commission, 2018, In-Depth Analysis in Support of the Commission Communication COM(2018) 773: A Clean Planet for all, A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy, Section 4, p.210.

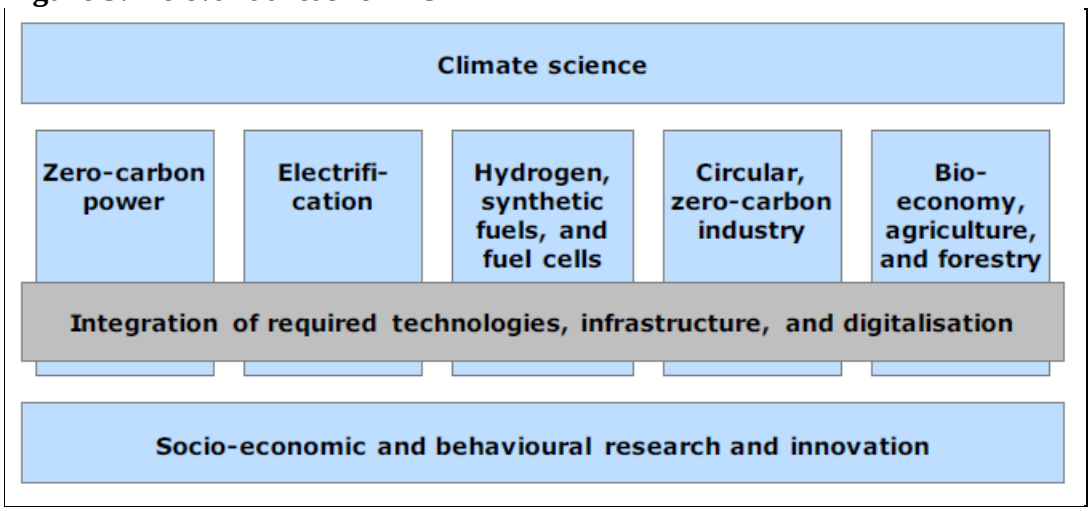
Table 6: Sectoral investment impacts in the EU (% deviation from the baseline)

2050	Fragmented action		Global action	
	80% reduction	1.5°C	80% reduction	1.5°C
Fossil-fuels industries	-40.6	-58.2	-40.4	-40.9
Electricity supply	8.5	21.9	7.4	26.3
Ferrous metals	-3.7	-9.4	3.3	6.7
Non-ferrous metals	-0.4	-1.1	1.0	5.2
Chemical Products	-1.1	-2.3	-0.9	-0.1
Paper products	0.8	1.2	1.8	6.5
Non-metallic minerals	-0.7	-2.4	0.9	2.7
Electric Goods	1.6	3.1	0.9	-3.9
Transport equipment	-1.3	0.8	-2.1	-3.4
Construction	2.0	3.6	1.7	3.0
Transport	-0.8	-3.1	-0.9	-6.1
Market Services	0.0	-0.4	-0.7	-2.7

Source: European Commission, 2018, In-Depth Analysis in Support of the Commission Communication COM(2018) 773: A Clean Planet for all, A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy, Section 4, Table 16, p.226.

The transition to a low-carbon or climate neutral economy will require the development of diverse technological and non-technological options for which R&I efforts are required. The next figure presents the main areas for research.

Figure 5: Relevant areas for R&I



Source: European Commission, 2018, In-Depth Analysis in Support of the Commission Communication COM(2018) 773: A Clean Planet for all, A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy, Section 5, p.242.

Social impacts

The low-carbon transition is not expected to affect overall employment in the EU significantly, however its effects will be diverse in the different sectors as summarised in the next table.

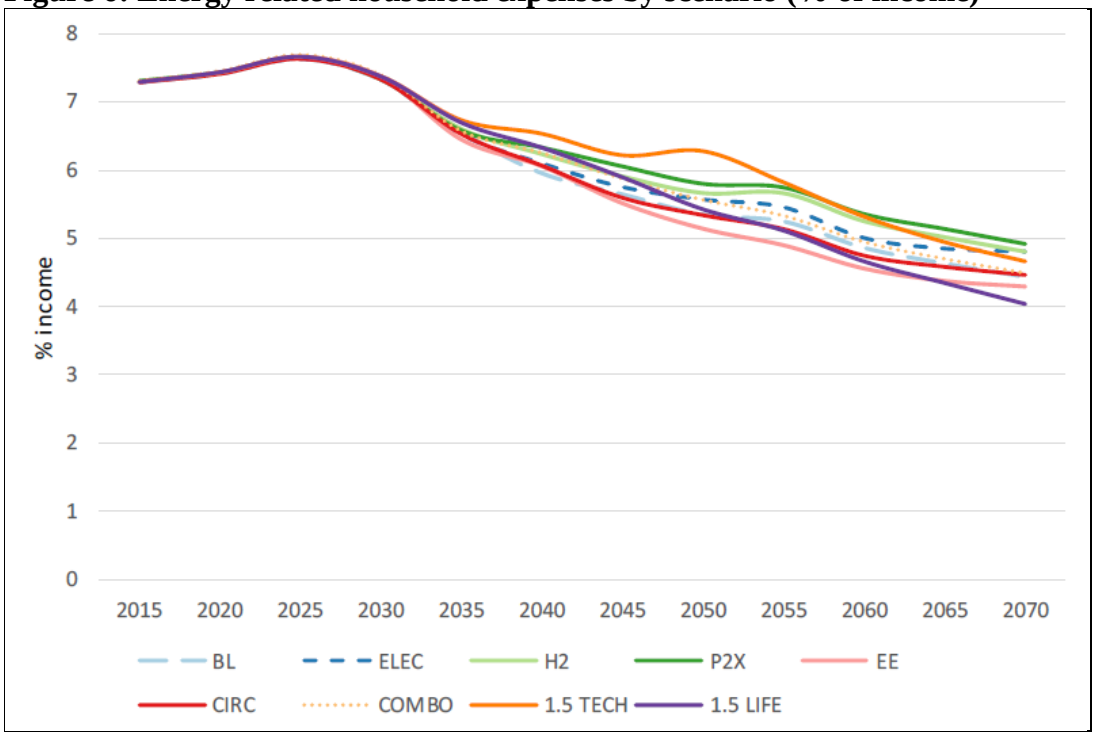
Table 7: Impacts of a low-carbon transition on employment by sector (EU level)

Sector	Share of jobs 2015	Impact and change in jobs by 2050		Assessment
Construction	6.7%	↑	+0.3% to +2.8%	Benefits from investment in RE technologies, EE and adaptation measures (extent will depend on investments); New skills might be needed to handle innovative building materials.
Services	71.7%	→	-2% to +0.9%	Benefits from more green procurement. New skills might be needed to master digitalisation in different sectors as well as green procurement; Impacts in the business, distribution and retail sub-sectors will depend on demand for services.
Agriculture	0.5%	↑	-0.7% to +7.9%	Benefits from investment in bioenergy; Positive impacts on ecosystem services might help protect jobs in the sector.
Mining and extraction	0.5%	↓	-62.6% to -2.9%	Risks from automation and global competition (trends already underway) and the shift away from fossil fuels.
Power generation	0.7%	↑	+3.6% to +22.3%	Benefits from more RE generation as it is more labour-intensive (extent will depend on demand and the options (EE measures may decrease demand and jobs but more electrification might increase those)).
Manufacturing (energy-intensive industries)	2%	→	-2.6% to +1.8%	Opportunities from the circular economy and the demand for manufacturing inputs for RE technologies (e.g. steel, aluminium) or buildings (e.g. cement, iron). Risks from carbon leakage and global competition.
Manufacturing (other)	13.3%	→	-1.4% to +1.1%	Benefits from investments in clean energy products and growth in other sectors (e.g. construction). New skills might be needed to handle structural changes due to electrification.

Source: European Commission, 2018, In-Depth Analysis in Support of the Commission Communication COM(2018) 773: A Clean Planet for all, A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy, Section 4, Table 17, pp. 227-229.

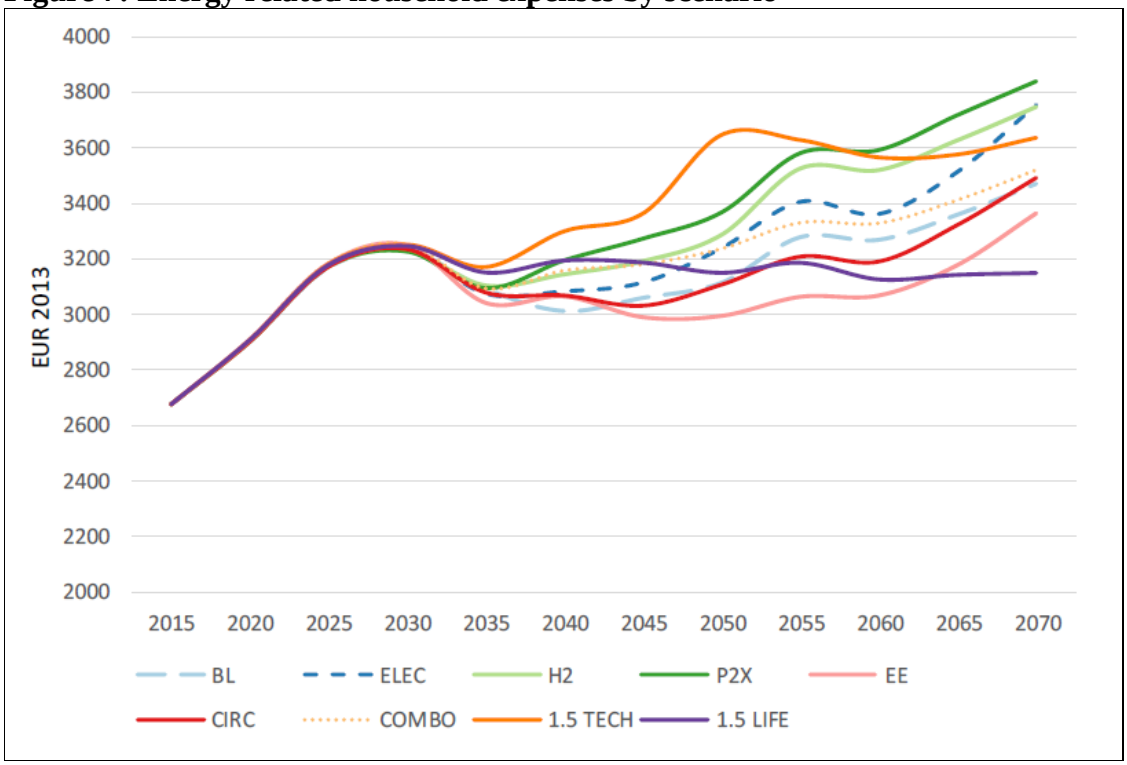
The energy related expenses of households are expected to grow until 2030 across all pathways but will diverge by scenario afterwards as shown in the following figures.

Figure 6: Energy related household expenses by scenario (% of income)



Source: European Commission, 2018, In-Depth Analysis in Support of the Commission Communication COM(2018) 773: A Clean Planet for all, A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy, Section 4, p.214.

Figure 7: Energy related household expenses by scenario



Source: European Commission, 2018, In-Depth Analysis in Support of the Commission Communication COM(2018) 773: A Clean Planet for all, A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy, Section 4, p.213.

Annex 3: Other additional information

Table 8: Key dates for NECP submission and updates

Deadline	Action	Legal reference
31/12/2018	**Member States** submit to the **Commission** their draft NECP	Article 9.1 GR
31/06/2019	**Commission** sends comments on draft NECPs to **Member States**	Article 9.2 GR
31/12/2019	Final NECP sent to **Commission**	Article 3.1 GR
01/01/2020	**Member States** submit their national long-term strategy to the **Commission**	Article 15.1 GR
31/10/2021	**Commission** assesses progress both at EU and national level	Article 29 GR
15/03/2023	**Member States** report to the **Commission** on implementation status of NECPs	Article 17 GR
30/06/2023	**Member States** send to the **Commission** a draft update of the NECP, or justify why no update is required	Article 14.1 GR
31/10/2023	**Commission** assesses progress both at EU and national level	Article 29 GR
31/12/2023	**Commission** sends comments on draft updates of NECPs to **Member States**	Article 14.6 GR
30/06/2024	Final update of NECP sent to the **Commission**	Article 14.2 GR
01/01/2025	**Member States** update their long-term strategy if necessary	Article 15.1 GR

Source: Own analysis.

Table 9: Upcoming international meetings with relevance for the negotiations under the Paris Agreement

Date	Location	Meeting
17-27 June 2019	Bonn	50th Sessions of the UNFCCC Subsidiary Bodies
17-27 June 2019	Bonn	World Climate Change Conference
23 September 2019	New York	UN Secretary General Climate Action Summit
26 September 2019	New York	High-level Dialogue on Financing for Development
2-13 December 2019	Chile	COP25

Source: Own analysis.

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European Committee of the Regions

Created in 1994 following the signing of the Maastricht Treaty, the European Committee of the Regions is the EU's assembly of 350 regional and local representatives from all 28 Member States, representing over 507 million Europeans.

Rue Belliard/Belliardstraat 101 | 1040 Bruxelles/Brussel | BELGIQUE/BELGIË | Tel. +32 22822211
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