WWF

BRIEFING PAPER

MARCH 2019

The EU long term climate strategy

WWF's assessment of the Commission's draft strategy and its supporting analysis.

On 28 November 2018, as requested by the European Council, the European Commission published a draft EU long term climate strategy, consisting of a 25-page communication supported by a 400-page staff working document (SWD). The strategy, titled "*A Clean Planet for all - A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy*", is not a legal document or an official EU position, but something that is now the subject of extensive discussions at both EU and Member State level. The intention is to submit an official EU long term strategy to the UNFCCC in 2020.

In general, the Commission deserves credit for producing a detailed and credible plan for how the EU can reach zero net emissions, explaining why that is essential and highlighting the benefits of such a transition for EU citizens. While the strategy should be more ambitious, ducks some tricky issues and contains serious flaws in relation to bioenergy and land use, it is nevertheless a very positive step forward. For the first time, this plan sees a major economy engaging seriously with its commitments under the Paris Agreement and the stark warnings delivered by the IPCC special report on 1.5°C.

This paper provides a comprehensive assessment of the strategy and its supporting analysis, identifies gaps and inconsistencies and makes recommendations on what the Commission and the Member States should do now.

[Blank page]

KEY TAKEAWAYS

Content of the strategy

The Commission's draft long term strategy sets out in stark terms the potentially catastrophic impacts of climate change, for example the risk of mass extinction of species and large-scale damage to human societies, and on the need for a transformation of every sector of the EU economy.

It also makes clear that this transformation is both technically feasible and economically desirable. Without even counting the benefits of avoiding climate change, the Commission estimates that a shift to zero net emissions would increase EU GDP by 2%, increase employment, deliver €200 billion per year in health benefits and save €2-3 trillion in fossil fuel imports.

On the nature of the transition:

- The Commission argues that the EU should aim to reach zero net emissions by 2050, but this ignores equity issues such as responsibility for historical emissions. WWF believes that the EU as a bloc should aim to reach zero net emissions by 2040.
- The strategy ducks the question of the EU's 2030 GHG target. But any cost effective trajectory consistent with staying below 1.5°C that doesn't require improbable rates of emission reduction after 2030 or massive future carbon dioxide removal would involve much faster cuts during the 2020s. The EU should revise its NDC accordingly, from 40% to 65%.
- The strategy rightly highlights the crucial role of energy efficiency, the need for a near-complete phase out of fossil fuels, including gas, and for a 'spectacular' increase in renewable energy, with wind and solar providing the vast majority of future supply in all sectors.
- As part of this transition the Commission calls for industrial modernisation to be at the centre of a fully circular economy, describing this as the next industrial revolution.
- In places the Commission fails to draw conclusions that are obvious from its underlying analysis, for example as regards decommissioning of the gas grid. While biogas and green hydrogen will have a niche role to play, heat networks are likely to be a much more cost effective solution to decarbonising heat supply in buildings and the EU should stop investing in gas infrastructure immediately.
- The strategy is seriously flawed as regards the issue of biomass and land use, arguing for a huge increase in the use of land for energy crops when all the evidence suggests this would be counterproductive in climate terms. The Commission is also dangerously complacent when it comes to forest biomass. As nearly 800 scientists warned last year[1], the lack of any meaningful restrictions in the new Renewable Energy Directive means that it poses a serious threat to the global climate and forests.

The Commission deserves credit, however, for arguing strongly for a fair and equitable transition. While reaching zero net emissions is essential, and beneficial for society as a whole, certain sectors and regions will need help to adapt.

Next steps

The strategy is currently being discussed in detail in the Council of the EU, with EU heads of state and government due to provide guidance on the issue at the June European Council. Under the Paris Agreement the EU is committed to submitting its agreed long term strategy to the UNFCCC, together with any updated 2030 NDC, by 2020.

WWF asks:

- The European Council should endorse as soon as possible and by June at the latest the aim of a **climate neutral EU by 2040**.
- The **strategic agenda** for the next European Commission should include that goal as a top priority and guiding principle.
- At the UN climate summit in September the EU should commit to increasing its **2030 NDC from 40% to 65%** and urge others to take similar action.
- The Commission and Member States should develop **EU and national strategies and plans** that are consistent with the emissions reductions required and with the science on bioenergy and land use.

[1] https://www.dropbox.com/sh/sqhn0b4h6dwvq65/AADnK8Q18AAFaCeWvbZ40vFGa?dl=0&preview=UPDATE+800+signatures_Scientist+Letter+on+EU+Forest+Biomass.pdf

[Blank page]

EXECUTIVE SUMMARY

WWF experts have carried out a comprehensive assessment of the 25-page communication and the 400-page staff working document, which can be found below. This executive summary provides a condensed version of that assessment, highlighting the most significant issues and making recommendations on further development of the strategy before a final version is submitted to the UNFCCC.

The Commission makes a compelling case for zero net emissions

The strategy sets out in stark terms the potentially catastrophic impacts of climate change, for example the risk of mass extinction of species and large-scale damage to human societies, and the need for a transformation of every sector of the economy. It also makes clear that the transition is something that is both **technically feasible and socially and economically desirable**. It suggests that, compared to the baseline, reaching zero net emissions by 2050 would increase GDP by 2%, increase employment (including 580,000 jobs in the circular economy), deliver €200 billion per year in health benefits and save €2-3 trillion in fossil fuel imports. Importantly, it says very explicitly that these benefits *do not take into account the benefits of avoiding climate change*, or the costs of failing to do so.

On the **level of ambition**, the strategy is very clear on the need to reach zero net emissions by 2050, rather than the 64% net reduction[2] that the Commission says can be expected under existing policies. However the justification for the 'net zero' goal – though compelling – see section 1 below – is barely mentioned in the strategy itself and is instead to be found in the SWD and its annexes. The strategy document also claims that the eight decarbonisation scenarios that the Commission has modelled[3] are "all in line with the Paris Agreement". Yet that phrase only appears in the high level document and it is clear from the analysis in the SWD that scenarios that only reach an 80% reduction in emissions by 2050 are in no way consistent with 'pursuing efforts' to limit global warming to 1.5°C. The Commission also ignores issues of equity, for example responsibility for historical emissions - one of the reasons that WWF believes the EU should be aiming to reach zero net emissions by 2040.

The strategy ducks the question of **the EU's 2030 GHG emissions target**. All the scenarios are based on existing policies up to 2030, and the Commission says it has no intention of proposing changes to the EU's 40% target. But any cost effective trajectory consistent with staying below 1.5°C that doesn't require improbable rates of emission reduction after 2030 or massive future carbon dioxide removal would involve much faster cuts during the 2020s than are shown in the Commission's baseline scenario. This is true whether zero net emissions are reached in 2040 or 2050. Interestingly, even the Commission's own baseline scenario involves emission reductions of 46%[4] in 2030, and the 1.5TECH and 1.5LIFE scenarios see this increasing to 47%[5], suggesting that a target well above the current 40% would be required to stimulate any additional investment. WWF believes that the EU should increase its 2030 GHG target from 40% to 65%, and revise its NDC accordingly.

The strategy puts 'energy efficiency first', and sees renewables growing spectacularly

The strategy recognises the crucial role of **energy efficiency** in achieving zero net emissions in the EU by 2050, and includes "efficiency first" as a central principle to be applied to policy making, planning and investment in the energy sector. This is particularly relevant in the buildings sector, where studies suggest up to 97% of the buildings built before 2010 will need to undergo some kind of renovation to comply with the net-zero emission objective, including deep renovation for the oldest and most inefficient. Given this it is disappointing that even the Commission's most ambitious scenario only sees final energy demand in 2050 fall by 47% compared to 2005, and that the Commission fails to identify the additional regulatory measures and financing instruments required

[2] Or, without removals by the LULUCF sink, a 62% reduction in emissions
[3] The eight scenarios take as their starting point the baseline scenario resulting from existing policies. The first five (ELEC, H2, P2X, EE, CIRC) each lead to a reduction of around 80% in GHG emissions by 2050 compared to 1990, or 85% including the LULUCF sink, and differ in the extent to which they prioritise different technologies or approaches. The sixth scenario (COMBO) brings all those options and approaches together and cuts emissions by 85%, or 90% including sinks. Scenarios seven and eight both achieve a 100% reduction in net emissions. Scenario seven (1.5TECH) relies on large amounts of bioenergy with carbon capture and storage, whereas scenario eight (1.5LIFE) involves a more circular economy, changes in lifestyles and natural approaches to carbon sequestration such as reforestation. There is also a low-biomass variant of the 1.5LIFE scenario (1.5LIFE-LB) which is effectively a ninth scenario. This scenario, which is described in the SDW but not the strategy, puts more emphasis on alternative technology options such as hydrogen and electrification.
[4] Or 48% net, including removals by the LULUCF sink
[5] Or 51% net, including removals by the LULUCF sink

to tap the available potential. The Coalition for Energy Savings has been working with research institutes to take an informed view of the issue and preliminary results seem to indicate that the EU could be more ambitious than the Commission suggests.

The Commission stops short of recommending a shift to 100% **renewable energy**. However the strategy projects that levels of such sources can be expected to increase 'in a spectacular manner' under all scenarios, rising from the 32% target level in 2030 up to 67-84% of (gross) final energy consumption in 2050, with **wind and solar power** delivering the vast majority of future supply. This is explained on the basis of the increasing competitiveness of such technologies and the facilitation of their deployment through new storage infrastructure and higher levels of demand side response.

The growth potential of **hydropower** is described as being limited "apart from small hydropower". This exception is worrying given that small hydropower delivers very little in terms of overall capacity but can have significant ecological impacts. There is very little discussion of wave, tidal or other forms of **ocean energy**, which the Commission notes face cost barriers and compete with other uses of seabed or coastal areas (which in WWF's view would include impacts on ecologically important coastal habitats). The ocean energy that is completely missing from the analysis is the potential for large scale marine heat pumps, as an extremely efficient supply source for district heating (see below).

The Commission rightly highlights the potential future role of **hydrogen** in the future zero-carbon economy, although is overly optimistic on the extent to which this is likely to be produced from fossil gas (using CCS) rather than from water (using wind and solar power). It is also bullish on the question of gaseous and liquid **e-fuels**, meaning those produced by reacting hydrogen with a source of carbon. But given the cost of direct air capture of CO_2, and the scarcity of sustainable biomass resources, it seems unlikely that such carbon-based fuels will ever play more than a niche role in decarbonising the energy system.

Despite the plummeting costs of wind and solar, there is a graph included in the analysis that seems to show **nuclear power** playing a greater percentage role in energy consumption, in all scenarios, than would have been expected under the baseline. It's hard to judge by how much, because the total energy demand is also lower, but it looks as though the Commission foresees at least some new nuclear build in coming decades. In recent presentations, the Commission has been clear that the extent of nuclear power deployment is a Member State issue, and realisty could be expected to vary from modelled scenarios accordingly.

Interestingly, the strategy notes that **CCS** is no longer seen to have the same potential as previously, because of the fall in the costs of wind and solar. But it still says that CCS will be needed for (mostly process related emissions in) industry, BECCS and hydrogen production. It also says (somewhat perversely) that CCS will increase the credibility of the EU's long term strategy, because new fossil plant built today will still be operating in 2050.

The sections on biomass and land use pose more questions than answers

The sections of the strategy and SWD on **biomass and land use** are the weakest parts of the analysis and in some places contradictory. On the one hand there is a welcome recognition that "land is a precious and finite resource" and that EU forests cannot supply increased biomass demand without that affecting the carbon sink. The strategy also recognises that reforestation – and the restoration of degraded natural ecosystems such as forests and wetlands – are an important source of 'negative emissions'. On the other hand the Commission talks about a "sustainable intensification of agriculture and forestry" and suggests that reaching zero net emissions requires an almost doubling of biomass use. This is despite the admission that while the burning of biomass for energy has increased from 1.8 mtoe in 2004 to 78.8 mtoe in 2016 "the impact of increased biomass demand…on the EU LULUCF sink is so far not very clear". Similarly, the Commission envisages a dramatic increase in the extraction of agricultural and forest residues for energy, but it is unclear how this fits with its call for reduced removal of residues to increase carbon retention in soils – or with the need to protect biodiversity and the rate of (forest) regrowth after harvest. Overall, the sections on biomass pose more questions than answers, which perhaps explains why the Commission felt the need to model a ninth 'low-biomass' scenario (see footnote 3, above).

On **agriculture** the Commission's analysis – which incidentally barely mentions the serious threat to EU agriculture posed by climate change – is mixed. On the plus side it notes that there are significant 'win wins' from

practices such as agroforestry and conservation agriculture, which both increase carbon sequestration in soils and landscapes and also provide numerous other benefits, for example water retention, soil fertility, productivity, prevention of soil erosion, nutrient retention and biodiversity protection. It also highlights the striking figures on 'organic soils': only 1.5% of EU cropland consists of such soils but they account for 55% of total cropland soil emissions, and the 3% of grassland on such soils emits as much carbon as is sequestered by the remaining 97%. However support from the CAP for cutting emissions from agriculture has been almost non-existent to date, and it continues to be a policy that largely supports the carbon-intensive livestock sector (see below). Supporting climate-friendly livestock production and changes to how 'organic soils' are used (e.g. through paludiculture[6] of peatlands and wetlands) would be a very cost-effective and environmentally sustainable approach to reducing emissions in the agriculture sector.

Where the Commission goes seriously wrong is in advocating a huge increase in the cultivation of **energy crops**, on up to 10% of agricultural land. This is based on a fundamental error in the model used, which assumes that large areas of unused or abandoned land are available at essentially no opportunity cost. But as numerous studies make clear, reforestation, or simply allowing land to revert to forest over time, typically delivers significantly higher net GHG impacts than using such land to produce biofuels, even accounting for the substitution of fossil fuels. The Commission says that "the substantial use of woody energy crops instead of stem forest feedstock wood limits the negative impact on the forest sink and therefore helps to maintain the overall LULUCF sink in all scenarios". Yet this is simply trading off one potential sink (the land it proposes be used for energy crops but that might instead be reforested) for another (land that is already forested). Such a policy may well 'help to reverse the trend in farmland abandonment and offer to farmers new economic perspectives', but it is not a policy that should be pursued on climate grounds. On the contrary, farmers should if anything be encouraged actively to return marginal or abandoned land to natural, carbon rich ecosystems. EU policies that prevent such an outcome (for example, requirements under the CAP that land be kept clear of vegetation) should be reviewed, and only accepted when the maintenance of agricultural activity has other explicit benefits such as biodiversity conservation.

The Commission pays lip service to the importance of **forests** in a climate context, but in places appears to argue that trees need to be cut down to stimulate the carbon sink, without adequately exploring the impact this has on carbon stocks in the forest as opposed to those in harvested wood products. The Commission also makes the mistake of thinking that the sustainability of any particular biomass-based energy feedstock from a climate perspective is related to the "net annual increment of the forest". In fact it depends primarily on what type of feedstock is being burnt, and the increased harvesting of forests for energy will likely increase emissions for decades to centuries compared to fossil fuels. Warnings along these lines and a call for the EU to limit bioenergy incentives to wastes and residues were made in a letter to EU lawmakers in 2018 signed by nearly 800 scientists, including multiple IPCC lead authors and winners of the Nobel Prize and US National Medal of Science[7]. However for reasons that are not clear, the climate and energy Commissioner Miguel Arias Cañete personally advised MEPs to vote against the amendment that would have done this, saying that it was not 'environmentally desirable'. The new Renewable Energy Directive therefore contains no restrictions at all on the types of forest biomass that can be burnt with subsidy and counted as being carbon neutral. It is near inevitable that the EU will be forced to perform a U-turn on this issue in the near future, as it was forced to do with its biofuels policy, as in its current form the Directive poses a serious threat to the global climate and forests.

As regards carbon dioxide removal (CDR), sometimes referred to as '**negative emissions**', the most promising option is to increase the natural sink, which the Commission notes can be achieved "through ecosystems restoration, afforestation, reforestation, improved forest management and enhancing soil carbon sequestration". Many of those options would also provide significant additional benefits, whether to agricultural productivity, water and flood management, biodiversity and human wellbeing, and their sustainable deployment should urgently be prioritised. As regards relying on more 'technological' approaches to CDR discussed in the SWD, the Commission notes that these are mostly "only at an exploratory stage and none of them are sufficiently mature for large deployment". This reinforces the need for very rapid reductions in emissions in all sectors; however difficult and costly such reductions may appear, they are likely to be much easier and cheaper than sucking CO_2 back out of the atmosphere after it has been emitted.

[6] https://en.wikipedia.org/wiki/Paludiculture

[7] https://www.dropbox.com/sh/sqhn0b4h6dwvq65/AADnK8Q18AAFaCeWvbZ40vFGa?dl=0&preview=UPDATE+800+signatures_Scientist+Letter+on+EU+Forest+Biomass.pdf

The Commission essentially dismisses the issue of **'imported' or 'embedded' emissions**, whether in relation to food or products, arguing (on the basis of somewhat limited evidence) that low carbon EU exports help reduce emissions elsewhere. While accounting of emissions under the UNFCCC is done at source, there is no solution to climate change that does not involve action to reduce EU imports of goods that drive emissions - notably through deforestation - elsewhere in the world. And so the Commission's reluctance to engage with this issue, in the same way that it avoids questions of equity related to historical emissions, is a disappointment and a missed opportunity.

Fossil fuels and the gas grid are history, but the future is bright for heat networks

The strategy document focuses on the positive aspects of the transition and ducks many of the issues relating to incumbent industries. It fails for example to draw explicit conclusions about the extent – and speed – of the phase out of **coal and other fossil fuels**. Coal is phased out in all eight scenarios and oil and gas use in the zero net emissions scenarios falls to around 15%, with half of that being for non-energy uses and fossil fuel imports falling by 70%.

One of the examples of this reluctance to draw conclusions relates to the **gas grid**. The Commission suggests in several places that there would be benefits in using "existing gas transport infrastructure", which it claims "will still be operational in 2050". It even states that "there is clearly a rationale" for doing so, but without providing any cost-benefit analysis. And while it suggests that the grid could cope with up to 15% (or in the future 20%) hydrogen by volume, it admits that an upgrade would be needed to accommodate higher levels of hydrogen and that "a renewed network" would likely be needed for pure hydrogen. The document says that natural gas or other gases will predominantly be used in industry and power generation, and in the 1.5LIFE scenario the use of all gases in the residential and services sector (natural gas, hydrogen, e-gas, biogas and gas from waste) falls from 150 mtoe in 2015 to about 40 mtoe in 2050. Therefore it is far from clear that the gas distribution network - and by implication the transmission system - will remain economically viable. Rather than use precious biogas or e-gas for low grade heat in buildings, and suffer the "trade-offs" that the Commission suggests could result in the longer term from "managing simultaneously multiple networks", it may well prove more cost-effective to decommission the gas grid in urban areas and replace it with district heating (see below). This in turn reinforces the need to ask serious questions about ongoing EU investment in additional gas infrastructure such as pipelines.

Another gap in the Commission's analysis is that there is very little in the SWD on the question of **heat**, which given that it accounts for perhaps half of all energy use is a major failing. Curiously, the Commission notes in one place that district heating, which today accounts for only 10% final energy consumption for heat, could have the potential to meet 50% in future, including 25-30% using large scale heat pumps. The results of the modelling, in contrast, show little change in the deployment of district heating compared to today. It's not clear why this is, but it may well be related to the technical difficulties of modelling district heating as opposed to individual technologies at building level. In general there are strong grounds for thinking that heat storage combined with district heating is likely to play a major role in decarbonising heat supply to buildings. This is particularly likely given the high costs associated with trying to solve the problem of peak heat demand – whether over daily, weekly or seasonal timescales – using building level electric heating or a decarbonised gas distribution network.

The vast majority of cars and vans will be battery powered

The strategy is clear on the need for a transformation in the **transport** sector, with the vast majority of cars and vans expected in future to be battery powered. The use of batteries is also projected to increase in lorries, although the Commission appears unduly pessimistic on this front and assumes that a mix of different drive chains can be expected, including internal combustion engines, hybrids, and, to a very limited extent, electric or fuel cell sources. This picture seems somewhat implausible, requiring as it would the costly development and long term co-existence of multiple different fuelling or charging infrastructures across the European continent, including for liquid fuels, gaseous e-fuels, hydrogen, battery powered lorries and lorries reliant on pantographs and catenary lines. On what it describes as "the biggest challenge", aviation, the Commission assumes (as for shipping) a heavy reliance on biofuels and e-fuels, and only in the 1.5LIFE scenario models a modest reduction in the rate of growth. There is wording however on putting all transport modes on an equal footing, including in regulatory and fiscal terms, which could be interpreted as a reference to the fact that aviation is seriously under-taxed compared to other forms of transport.

Huge opportunities exist to invest in the clean industries of the future

The strategy is positive on the need for "putting **industrial modernisation** at the centre of a fully circular economy" and the need for the full decarbonisation of resource and energy intensive industries in Europe. It describes this as the 'next industrial revolution' and 'the circular industrial transformation'. And the analysis accompanying the strategy shows vast opportunities exist now in high-emitting sectors such as steel, cement and chemicals to deliver a zero-carbon transition through circularity, investment in energy saving, renewable energy and clean breakthrough technologies. This is an important shift in mindset, but the Commission fails to set out any new policies or a climate-proof industrial strategy commensurate with the required ambition - despite industry associations calling for a clear industrial policy agenda.

There is significant emphasis on the need for increased **investment** to achieve the transition to a climate neutral economy (in the range of €175 to €290 billion per year compared to the baseline). And page 235 of the SWD goes into detail about the need for change in the financial sector, giving some helpful examples of the role of governments in shaping sustainable incentives for investment (for example better debt financing has increased investment in wind power by 15%). However the Commission notes that"investment in low-carbon technologies still accounts for a very small share of institutional investors' assets" and that some recent analysis "found that the share of green investment in the portfolios of pension funds and insurance companies is around 1-2%". The Commission is also guilty of cherry-picking when it comes to existing EU policies, highlighting the climate-friendly parts of the EFSI and cohesion policy but omitting to mention the many billions spent under such instruments and the CAP on carbon intensive infrastructure and approaches.

A socially fair transition that involves EU citizens in decisions is essential

Explicit reference is made to, and emphasis placed on, the need for a '**socially fair transition**'. There are also text and maps that illustrate how the transition could disproportionately affect European Member States with low income levels and fossil or car industry-dependent sectors. While the socio-economic impacts of the transition at EU level will be positive, this aspect of the strategy will therefore be crucial to winning support from all countries and regions, and hence to its overall success. The EU should take such issues fully into account in negotiations on the MFF and in all relevant future policy development.

There is rather little in the strategy on the question of consumer **lifestyle choices and diets**. This was an intentional political decision, but the issue is not something that can easily be ignored and is likely to become a significant topic in the debate, particularly given the connection to agricultural emissions and the 'embedded' emissions linked to deforestation and land use, which are not covered by the EU strategy. The SWD is better in this regard, highlighting the dramatic impact of food waste and red meat and dairy consumption on emissions. As the Commission says, "limiting food waste, engaging on active mobility or healthier diets are now mainstream consumer considerations in Europe and other options could follow this suit, including limiting fast growth in long distance travel and shifting to more sustainable transport modes like rail, or limiting the purchase of new consumer goods."

Public and stakeholder engagement in planning is critical, and there is some limited coverage in the SWD of the **governance** issue, with the Commission noting that, under the new Governance Regulation, "National energy and climate plans are required to be consistent with both the EU long-term strategy and the national Long Term Strategies to be submitted by January 2020. While this point is important and welcome, there is no explanation of how such consistency will be assessed or enforced, particularly as regards the national long term strategies, which may only be finalised by 1 January 2020.

FULL ASSESSMENT

The following pages contain WWF's assessment of the SWD, arranged according to the content headings of that document. It attempts to summarise what each section says, identify where the gaps are and what therefore requires further analysis and discussion over coming months. The SWD is available online here.

1. Introduction and context

This short section and the annex that accompanies it (section 7.3) explain why the EU needs to develop a long term strategy and explore the level of ambition required. On the latter, it starts by noting that current NDCs are consistent with pathways that reach 3°C of warming by 2100 and would not keep temperatures below 1.5° even if there were 'very challenging' emissions reduction after 2030. Drawing on analysis by the IPCC, the Netherlands Environmental Assessment Agency and the European Commission's own Joint Research Centre it then goes on to argue that:

- There is no official definition of 'well below 2°C' but studies typically refer to pathways with a better than 66% chance of keeping global warming below that temperature, meaning a 50% chance of 1.7-1.8°C in 2100.
- To have a better than 66% chance of staying below 2°C global net GHG emissions need to fall by 50% by 2030 and to zero by 2100.
- To have a 50-66% chance of staying below 1.5°C, with no or limited overshoot[8], net GHG emissions need to fall faster, reaching zero just before 2070 (with net CO_2 emissions reaching zero even earlier, meaning around 2050).
- Scenarios with no or limited overshoot of 1.5°C and that don't rely heavily on negative emissions later in the century see global net GHG emissions reaching zero by 2050 (and net CO_2 emissions well before that).

This section also discusses what the various levels of global ambition imply in terms of EU effort, again drawing on work by the Dutch agency and the JRC. The Commission argues that an 80% reduction in net EU GHG emissions by 2050 would be consistent with the 'well-below 2°C' goal (and global net GHG emissions reaching zero in 2100), and that a 91-96% reduction would be consistent with staying below 1.5°C (and global net GHG emissions reaching zero in 2070). Such pathways are based on what action it would be 'efficient' for the EU to take as part of a cost optimal global approach, and under most such scenarios the EU would not be the first large emitter to reach zero net emissions.

The Commission briefly mentions other approaches, citing some 2017 research that suggests that if the global allocation of emissions were based on "convergence towards equal annual emissions per person", the EU's 2050 GHG target would need to be 75% for a 'well below 2°C' pathway and 90% for a 1.5°C target. However it also notes that a 'per capita convergence' approach to 1.5°C that didn't rely on negative emissions would mean an EU 2050 target approaching 100% (i.e. zero net emissions) - as would an approach based on GDP per capita. The Commission doesn't appear to have considered any more equitable approaches, for example a per capita allocation of the remaining carbon budget without any 'convergence', but it admits that if responsibility for historical emissions were taken into account the EU would have to reach zero net emissions *before* 2050.

In conclusion, although it doesn't make this case explicitly, and - bizarrely - doesn't do so at all in the high level Communication, the Commission provides clear and compelling arguments in the SWD in support of the EU reaching zero net emissions by 2050 or even earlier. These include:

- The very serious risks and impacts associated with exceeding 1.5C - even temporarily
- That estimates of the remaining global carbon budget are highly uncertain and could be revised downwards dramatically
- The high risks associated with over-reliance on negative emissions technologies, something that the Commission notes was raised by many stakeholders
- That delay would mean much more rapid action would be needed later, something that would ultimately be more costly - if indeed it were possible at all
- That based on the precautionary principle, there is a strong argument for the world cutting emissions faster than the median scientific estimates suggest is necessary
- That delay increases the risk of lock-in to carbon intensive infrastructure, meaning stranded assets

[8] Generally meaning overshoot of no more than 0.1°C

- That from an economic perspective, acting early represents an opportunity for change and innovation, and for the EU to reap the benefits of first mover advantage in the industries and services of tomorrow (including high value intellectual property rights to low carbon technologies)
- The fact that there is strong support for net zero or even earlier (WWF for example has called for the EU to aim for 2040). There is also strong support for the zero net emissions goal in the results of the Commission's public consultation, which are summarised in section 7.1 of the document. 53% of individuals and 54% of organisations thought that the EU should commit to reaching zero net emissions by 2050 (the most ambitious option available in the consultation) with only 16% of each thinking that an 80% reduction would be adequate.

These reasons for reaching zero net emissions by 2050 (or earlier) are of course in addition to the many co-benefits that result more generally from the action needed to stop climate change, including for example:

- Health and quality of life benefits (clean air, reduced noise, better diets, more efficient mobility)
- Positive impacts on employment and GDP
- Lower energy bills and increased home comfort
- Energy independence
- Reduced demand for raw materials (through circularity)
- Ecosystem protection and restoration
- Maintenance of the health and productivity of natural systems, including soil fertility
- Water management and flood risk reduction
- Less pollution (e.g. nitrates, mercury from burning coal etc)
- Soft power and a boost to global credibility

2. EU action to date reducing ghg emissions and transforming its energy system

This rather lengthy (over twenty page) section consists of upbeat descriptions of EU policies to cut emissions, their implementation by Member States and the positive role played by regions, industry and civil society. Most of this is uncontentious and of only passing interest, but there is a fair amount of 'greenwashing', particularly in relation to the Common Agricultural Policy (CAP), cohesion policy and the MFF. The following points are worth noting:

- The Commission claims that there has been "…a **decoupling of economic growth from GHG emissions** and energy consumption…", but admits that emissions increased slightly in 2015 and 2017 and that energy consumption has been rising since 2014 "…in part due to…continued economic growth…".
- 50% of EU energy demand is for heat and nearly 20% of that is now from renewable sources. However most of this (80%) comes from burning solid **biomass**, which has increased from 1.8 Mtoe in 2004 to 78.8 Mtoe in 2016. Figures are not provided for the significant increase in biomass burnt for electricity generation. Despite this the Commission notes - worryingly - that "the impact of increased biomass demand since 2009 on the EU LULUCF sink is so far not very clear…". It also says that "rules and incentives for food, feed, fibre production and bioenergy may variously support or undermine the historical trend of a stable overall sink in the EU". On the plus side from a climate perspective it notes that "the significant emergence of energy crops on economically marginal agricultural land has yet to materialise…".
- The Commission notes that "**national energy and climate plans** (NECPs) are required to be consistent with both the EU long-term strategy and the national Long Term Strategies (LTSs) to be submitted by January 2020". This is welcome, although it's not clear how the Commission intends to assess this given that unlike for the NECPs no draft version of the the LTSs is required.
- The section on the **Common Agricultural Policy** (CAP) fails to mention the elephant in the room, namely that the CAP funds carbon intensive farming to a vastly greater extent than low carbon farming. The text is therefore extremely misleading, to the point of it constituting complete greenwashing. The cross-compliance mechanism the "greening" approach are both weak and full of loopholes, and there are hardly any agri-environment-climate schemes that specifically target climate change mitigation.
- On **cohesion policy**, as with the CAP, the Commission is extremely selective, covering only the climate-friendly parts and ignoring the retrograde aspects that support fossil fuels, high carbon transport, etc.
- As regards the **MFF and climate mainstreaming in financing**, the Commission is again guilty of cherry-picking, for example mentioning the climate-friendly part of European Fund for Strategic Investment (EFSI) and noting that "regular monitoring data indicates that the energy is one of the

largest policy area of operations financed under the EFSI, representing 20% of total EFSI support" but completely omitting the many billions devoted to new or bigger motorways, airports, gas pipelines etc. WWF has called for a 50% target for climate and environment spending in the forthcoming MFF rather than just a 25% climate target. It's also important to note that while for the current MFF "the EU decided to commit 20% (over EUR 206 billion) of the overall budget to climate change" this has - according to the EU itself - not been achieved.

3. Impact of current policies beyond 2030

This 7-page section and related material in the annex (section 7.2.2.1) sets out what the Commission expects to happen to EU emissions based on known policies. It establishes a 'baseline' that takes into account the 2016 reference scenario, but also the new EU 2030 targets on energy efficiency and renewable energy that were agreed in 2018 and various other policies that can be expected to affect emissions up to (and beyond) 2030. The Commission projects that under this baseline scenario:

- Compared to 2005 levels, primary energy consumption declines by 26% by 2030, 35% by 2050 and then remains stable.
- Domestic production of fossil fuels falls by 88% by 2050 (again, compared to 2005) and net fuel imports fall by 33% over the same period. Renewable energy more than doubles, while nuclear declines slightly.
- EU GHG emissions can be expected to decline by 46% relative to 1990 levels by 2030, and by 62% by 2050 (due to the impact beyond 2030 of policies such as the EU Emissions Trading Scheme).
- To break this down further, CO_2 emissions fall by 65% by 2050 compared to 1990 levels whereas non-CO_2 emissions only decrease by 50% (and all of that is achieved by 2030 - after which those emissions - two thirds of which are agriculture - remain stable).
- The LULUCF sink declines from around 300 $MtCO_2$ in 2015 to 260 $MtCO_2$ in 2050, due to "the ageing of the forest and an increasing mobilisation of forest biomass, mainly for material use…". The potential impacts of climate change-related forest fires or droughts is not assessed.
- Net GHG emissions (i.e. including the LULUCF sink) would fall by 48% by 2030 relative to 1990 levels and by 64% by 2050.

4. Sectoral and economy wide low carbon and energy transformation pathways

4.1 Overview and scenario description

This short section describes the eight main scenarios that the Commission has modelled (using a variety of modelling tools that are described further in the annex (section 7.2). These have as their starting point the baseline scenario resulting from existing policies, which as described above is expected to lead by 2030 to a 48% reduction in net GHG emissions, compared to 1990 levels, and to a 64% net reduction by 2050.

The first five scenarios (ELEC, H2, P2X, EE, CIRC) each lead to a reduction of around 80% in GHG emissions by 2050 compared to 1990, or 85% including the LULUCF sink, and are said to be consistent with "well below 2°C". They differ in the extent to which they prioritise options such as electrification, hydrogen, e-fuels (i.e. power-to-X), end user energy efficiency and the role of a circular economy.

The sixth scenario (COMBO) brings together all the decarbonisation options in the first five scenarios, but at lower levels, and leads to a GHG reduction of 85%, or 90% including sinks. Under this and the first five scenarios the effect of mitigation efforts continues after 2050, meaning that emissions continue to fall towards zero thereafter.

Scenarios seven and eight both see net GHG emissions falling to zero by 2050, and on this basis are argued to be consistent with "pursuing efforts" to keep global warming below 1.5°C. Scenario seven (1.5TECH) "pushes all zero-carbon energy carriers as well as efficiency, and relies on a negative emissions technology in the form of bioenergy combined with carbon capture and storage (BECCS) to balance remaining emissions". Scenario eight (1.5LIFE) "relies less on the technology options of scenario seven" but assumes a move to a highly circular economy, changes in lifestyles and consumer choices and a stronger role for the land use sink instead of negative emissions technologies.

The Commission has also modelled a low-biomass variant of the 1.5LIFE scenario (1.5LIFE-LB) which is in some places referred referred to as 'sensitivity testing' but is effectively a ninth scenario. This scenario, which is described in the SDW but not the Communication, puts more emphasis on alternative technology options such as hydrogen and electrification. There is a useful table (see below) summarising the eight main scenarios on page 56 of the document.

Long Term Strategy Options

	Electrification (ELEC)	Hydrogen (H2)	Power-to-X (P2X)	Energy Efficiency (EE)	Circular Economy (CIRC)	Combination (COMBO)	1.5°C Technical (1.5TECH)	1.5°C Sustainable Lifestyles (1.5LIFE)
Main Drivers	Electrification in all sectors	Hydrogen in industry, transport and buildings	E-fuels in industry, transport and buildings	Pursuing deep energy efficiency in all sectors	Increased resource and material efficiency	Cost-efficient combination of options from 2°C scenarios	Based on COMBO with more BECCS, CCS	Based on COMBO and CIRC with lifestyle changes
GHG target in 2050	-80% GHG (excluding sinks) ["well below 2°C" ambition]					-90% GHG (incl. sinks)	-100% GHG (incl. sinks) ["1.5°C" ambition]	
Major Common Assumptions	• Higher energy efficiency post 2030 • Deployment of sustainable, advanced biofuels • Moderate circular economy measures • Digitilisation				• Market coordination for infrastructure deployment • BECCS present only post-2050 in 2°C scenarios • Significant learning by doing for low carbon technologies • Significant improvements in the efficiency of the transport system.			
Power sector	Power is nearly decarbonised by 2050. Strong penetration of RES facilitated by system optimization (demand-side response, storage, interconnections, role of prosumers). Nuclear still plays a role in the power sector and CCS deployment faces limitations.							
Industry	Electrification of processes	Use of H2 in targeted applications	Use of e-gas in targeted applications	Reducing energy demand via Energy Efficiency	Higher recycling rates, material substitution, circular measures	Combination of most Cost-efficient options from "well below 2°C" scenarios with targeted application (excluding CIRC)	COMBO but stronger	CIRC+COMBO but stronger
Buildings	Increased deployment of heat pumps	Deployment of H2 for heating	Deployment of e-gas for heating	Increased renovation rates and depth	Sustainable buildings			CIRC+COMBO but stronger
Transport sector	Faster electrification for all transport modes	H2 deployment for HDVs and some for LDVs	E-fuels deployment for all modes	Increased modal shift	Mobility as a service			• CIRC+COMBO but stronger • Alternatives to air travel
Other Drivers		H2 in gas distribution grid	E-gas in gas distribution grid				Limited enhancement natural sink	• Dietary changes • Enhancement natural sink

The options in each sector that are taken up in the various different scenarios are assessed further below. But it is clear that none of the scenarios is consistent with the WWF view that the EU should aim to reach zero net emissions by 2040, not 2050. And of the two that come close - i.e. that reach zero net emissions in 2050 – WWF's preference would be for scenario eight, or ideally the low biomass variant thereof, on the grounds that is doesn't rely heavily on BECCS.

In the 25-page Communication, although not in the SWD, the Commission claims that the eight scenarios are "all in line with the Paris Agreement". This looks very much like a phrase that may have been added at a late stage, during political level negotiations, and is not correct. The first five scenarios are - at best - consistent with 'well-below 2°C' and are certainly not consistent with 'pursuing efforts' to stay below 1.5°C. Indeed even the Commission's 1.5°C scenarios are arguably inconsistent with the Paris Agreement, because they are based on a cost-optimal global approach and do not "reflect equity and the principle of common but differentiated responsibilities and respective capabilities".

4.2 Energy supply

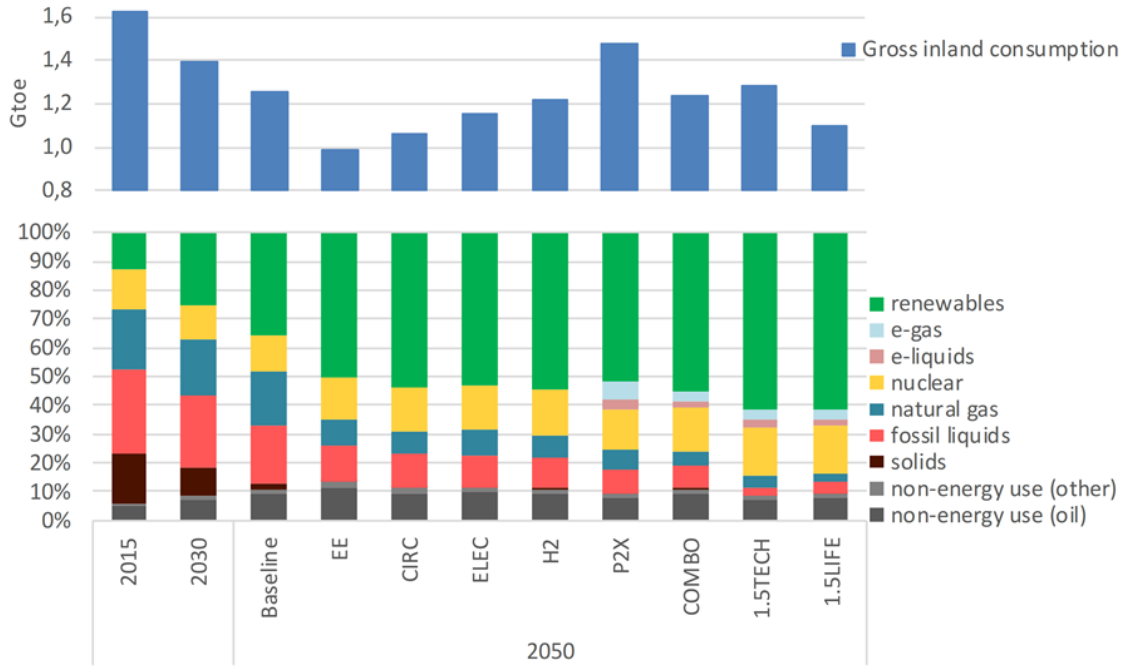
This 30-page section provides a detailed description of the EU energy system as it currently stands and an overview of the options for decarbonising it - which as it notes are to a large extent already available on the market. It then examines how those options are deployed under the eight different scenarios that the Commission has modelled. While focused on energy supply, it also covers energy demand in general terms (although the detail on the demand side is covered in later sections on specific sectors such as buildings, transport and industry). The key points to note in this section are as follows:

Energy efficiency first is rightly highlighted as a guiding principle for policy making, planning and investment in the energy sector. In short, the strategy advises considering exploring solutions to reduce energy demand before going ahead with supply side options. Even under the baseline scenario *primary* energy consumption is "substantially reduced" compared to 2005, by 26% in 2030 and by 35% in 2050 (see the top section of figure 18 below). The 'EE' and 'CIRC' scenarios deliver even greater reductions, of 50% and 45% respectively, although the zero net emissions scenarios achieve something closer to the reductions in the baseline, due to the increased electricity demand for e-fuels and hydrogen (see below).

As regards the fall in *final* energy consumption compared to 2005, this ranges from 30% under the 'P2X' scenario to as much as 47% in the '1.5LIFE' scenario. Residential energy consumption is what falls most sharply in most scenarios, followed by transport - due largely to the substitution of inefficient internal combustion engine vehicles with electric vehicles. While it is difficult to take a definitive view on the energy demand reduction potential in the EU, the Coalition for Energy Savings has been working with research institutes to take an informed view and the results[9] seem to indicate that the EU could be more ambitious than the Commission suggests.

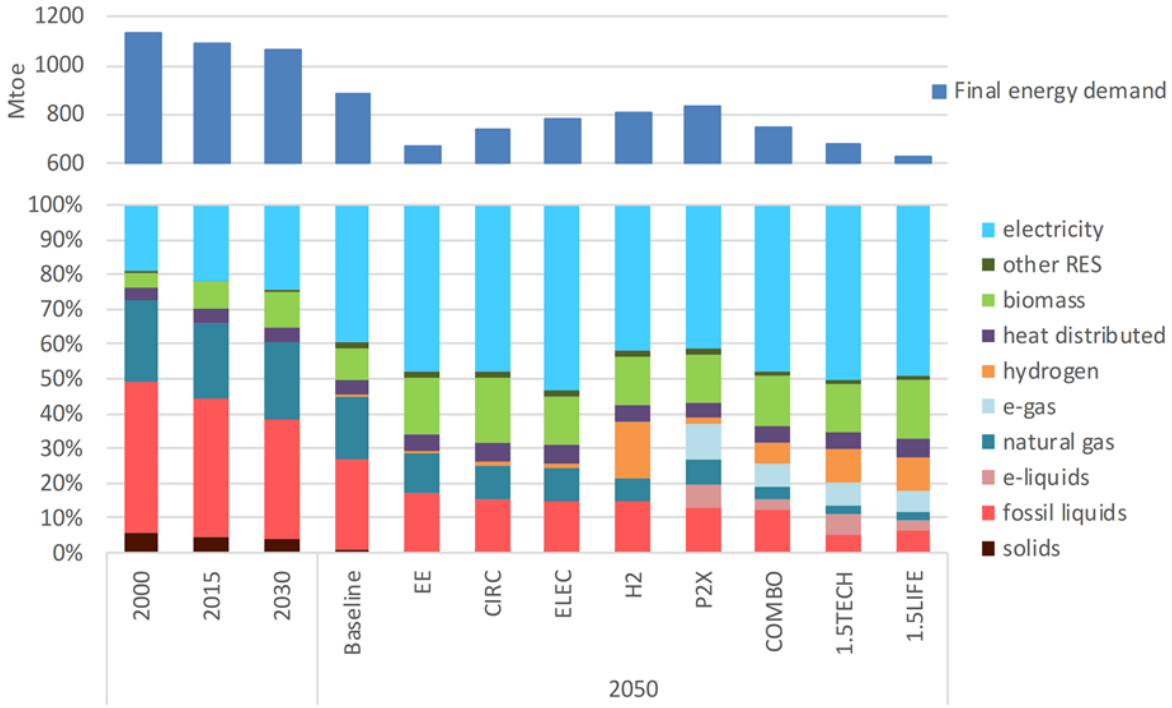
[9] https://www.isi.fraunhofer.de/en/competence-center/energiepolitik-energiemaerkte/projekte/energy-saving-scenarios-2050.html

Figure 18: Gross inland consumption



Renewable energy sources (RES) are expected to play a key role in all decarbonisation scenarios and in the public consultation were judged by stakeholders to be the most important technology. The Commission expects levels of RES are expected to increase "in a spectacular manner", rising from the 32% target level in 2030 to 67-84% of (gross) final energy consumption in 2050, with wind and solar delivering the vast majority of future supply. This is due to increasing competitiveness of those technologies and the facilitation of their deployment thorough new storage and demand-side response infrastructure. Somewhat disappointing is that RES are all described as being 'carbon free', which is both technically impossible and for some types of bioenergy very far from the truth. But in general the clear messages from the Commission on the need for a massive increase in wind and solar are welcome.

Figure 20: Share of energy carriers in final energy consumption

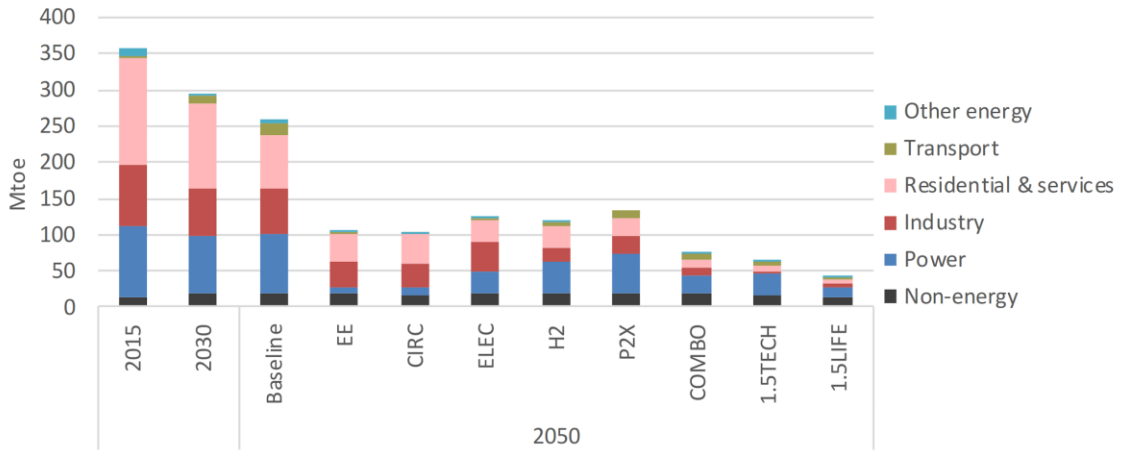


The Commission notes that **biomass** currently accounts for more than half of all RES generation and has recently seen significant growth. It also describes biomass-fired power plants as 'fully dispatchable', although solid biomass plants suffer the same problems of inflexibility as coal-fired plants. More generally, figures on biomass use are hard to find in the document and it's not clear how much or what types of biomass are deployed in the various scenarios. The Commission says for example that "the share of biomass and waste [in power generation] remains quite stable across scenarios" at around 7-8%, rising to 10% in the 1.5TECH scenario, due to BECCS. But it's not clear what fraction is (non-organic) waste and what fraction biomass. As regards biogas, the Commission suggests that consumption could nearly double by 2030, reaching 30 Mtoe compared to 16 Mtoe in 2015, and then increase further, depending on the scenario, to 45-79 Mtoe in 2050. However again it's not clear (from figure 29) if this is all biogas or includes gas from (fossil fuel-based) waste. The sustainability aspects of bioenergy are discussed in later sections, although the Commission does admit here that there are questions about trade-offs with food security and biodiversity. The Commission also says that "sustainable" solid biomass imports are "kept limited" (for reasons that are not given but can be guessed at) to 4-6% of the solid biomass used for energy in 2050, and that the GHG impacts outside the EU of increased biomass imports were not assessed.

The growth potential of **hydropower** is described as being limited "apart from small hydropower". This exception is worrying given that small hydropower delivers very little in terms of overall capacity but can have significant ecological impacts. There is very little discussion of wave, tidal or other forms of **ocean energy**, which the Commission notes face cost barriers and compete with other uses of seabed or coastal areas (which would include impacts on ecologically important coastal habitats). The ocean energy that is completely missing from the analysis is the potential for large scale marine heat pumps, as an extremely efficient supply source for district heating (see below).

Fossil fuels remain part of the energy mix under all scenarios, although coal is phased out in all eight scenarios and oil and gas use in the zero net emissions scenarios falls to around 15%, with half of that being for non-energy uses (see figure 28 on natural gas, below) and demand being partially substituted by e-fuels and e-gas. This in turn results in a fall in fossil fuel imports of over 70% in the zero net emissions scenarios.

Figure 28: Consumption of natural gas by sector



Note: "Residential and services" also includes agriculture.

Source: Eurostat (2015), PRIMES.

The text on **Carbon Capture and Storage (CCS)** (and Carbon Capture and Utilisation (CCU)) is somewhat mixed. On the one hand, the Commission mentions concerns as to economic performance, public acceptance and uncertainties on the behaviour of long term storage, and points out that capturing more than 90% of the CO_2 emitted "appears difficult and very costly to achieve, meaning CCS used with fossil fuels currently does not achieve full decarbonisation". It also mentions the uncertainty as to the climate mitigation potential of CCU and that the role of CCS in the power sector "is very limited in all scenarios as competitive wind and solar, as well as biogas, hydrogen, batteries and biomass are available in sufficient quantities to balance [the] electricity system".

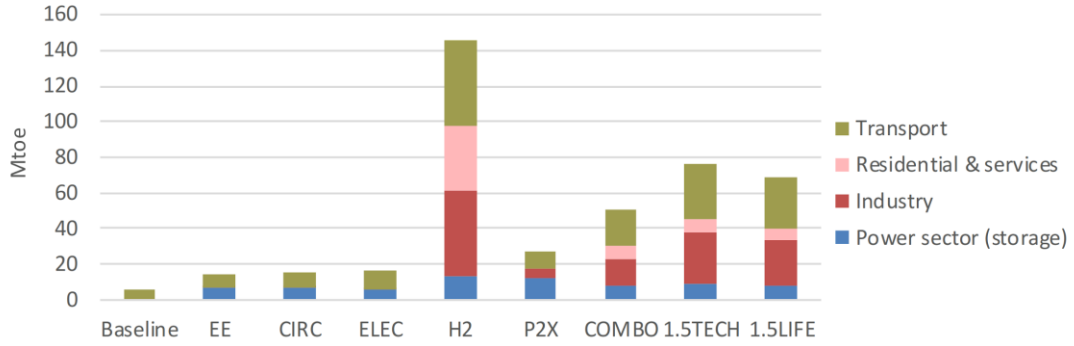
On the other hand it says that the role of CCS and CCU in reducing emissions in industry "has been recognised" and that it is often referred to as a "bridging technology", for example in combination with the use of natural gas as a 'transition fuel' for electricity sector balancing. The latter is something to be challenged, given that it would not be compatible with a fully decarbonised energy system and given the uncertainties associated with CCS deployment at scale - meaning CCS risks being used to justify the ongoing use of fossil fuels. The Commission's assertions that "CCS and CCU lie in the critical path for scenarios where negative emissions would be needed" and that "CCS technology…is critical for achieving net-zero emissions, as required to reach the 1.5C goal of the

Paris Agreement" should also be challenged, on the grounds that this contradicts text elsewhere in the document on the potential for negative emissions through natural means, for example the restoration of forests and other ecosystems.

Nuclear power is mentioned in various parts of this section, but the Commission is careful not to take a position on the desirability or otherwise of its future use in the EU, in line with the choice of energy mix being a matter of national sovereignty for Member States. While noting that nuclear power is expected to play a role in decarbonisation at a global level the Commission points out that investment in new nuclear remains challenging, due to upfront costs, public acceptance issues and uncertainty as to future electricity market prices, particularly with increasing volumes of variable renewable energy. Developing a permanent solution for nuclear waste disposal is also highlighted as a key challenge, although the costs related to decommissioning nuclear infrastructure, management of nuclear waste and (typically uninsured) losses in the event of nuclear accidents are not quantified. The Commission highlights other issues with nuclear (including public acceptance), but also suggests it could be a source of flexibility in electricity generation through the development of small modular reactors (SMRs). In terms of the modelling, nuclear continues to play a role in all scenarios, remaining at approximately the same level as at present in terms of the overall generation mix.

Hydrogen is seen by the Commission as playing a significant role in the future energy system, both as an energy storage mechanism and as a vector for (primarily) industry and transport (see figure 32 below). Several of the scenarios modelled involve significant increases in hydrogen production, which could be from industrial scale electrolysis or from steam methane reformation of natural gas combined with CCS, "provided the inherent constraints of CCS are lifted".

Figure 32: Consumption of hydrogen by sector in 2050

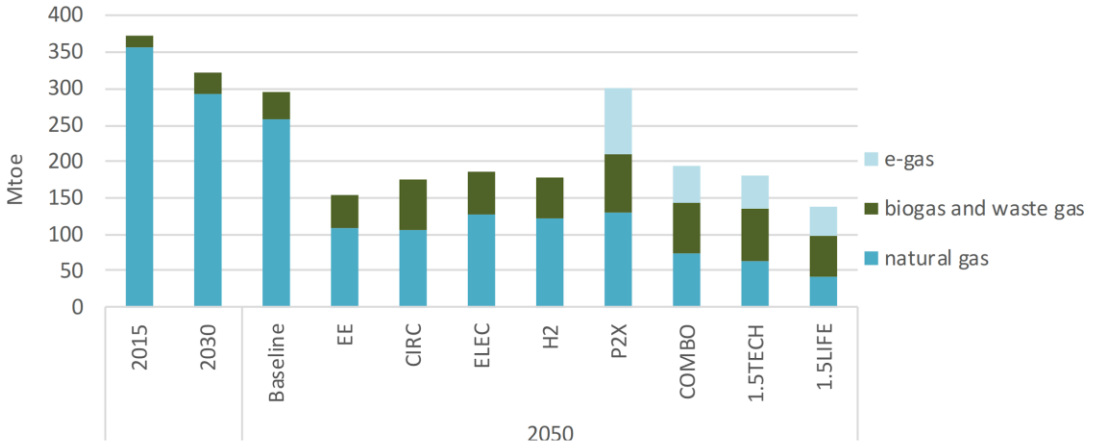


Note: "Residential & services" also includes agriculture.

Source: PRIMES.

As regards **e-gas**, meaning synthetic methane produced by combining hydrogen with a source of carbon (biomass or direct air capture), this is only deployed in the P2X scenario, and to a lesser extent in the COMBO and zero net emissions scenarios. Somewhat surprisingly, given that this isn't the case for hydrogen or biogas, this is used to some extent in the residential sector, as an alternative to natural gas. Overall the Commission envisages gas of various types continuing to play a role in future energy scenarios (see figure 31 below) but at much lower levels than today and – depending on the type of gas – in a restricted number of sectors.

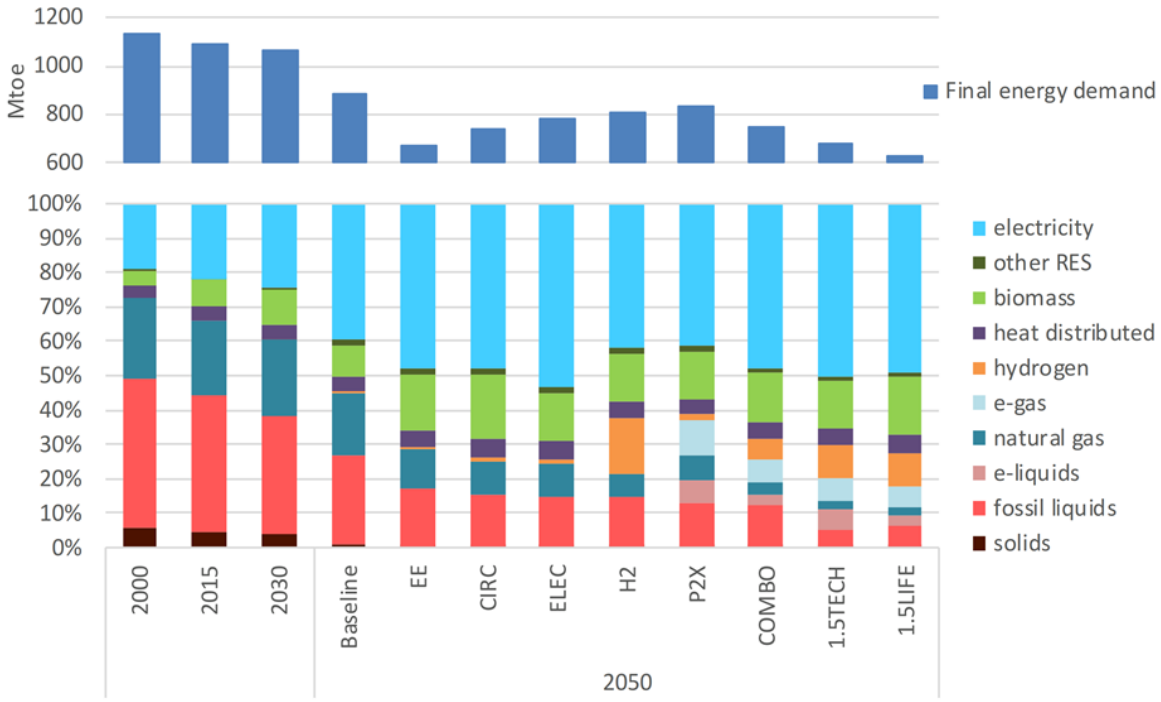
Figure 31: Total gas consumption per gas type



Source: Eurostat (2015), PRIMES.

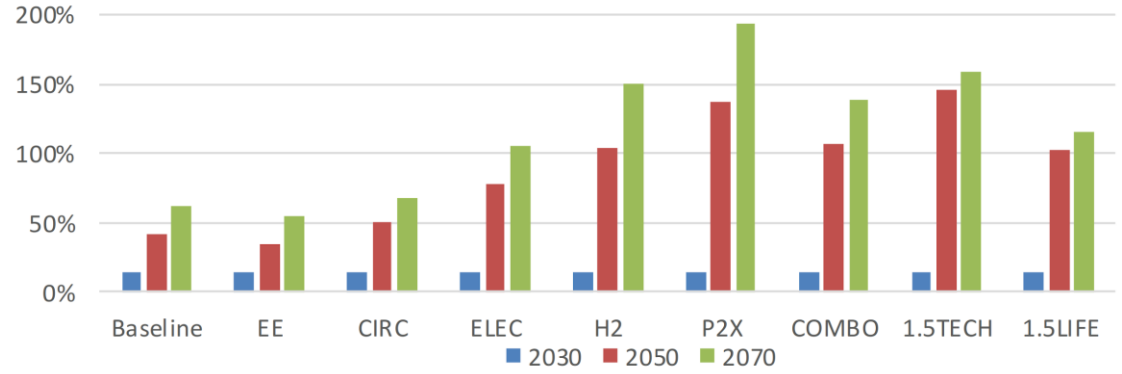
E-fuels, meaning liquid fuels produced from hydrogen and a source of carbon, are deployed to a limited extent in the P2X, COMBO and zero net emissions scenarios, in the transport sector. As the Commission notes, these are likely to be high cost, but notes that supply and trade of such commodities internationally might be part of the transition in the longer term.

Figure 20: Share of energy carriers in final energy consumption



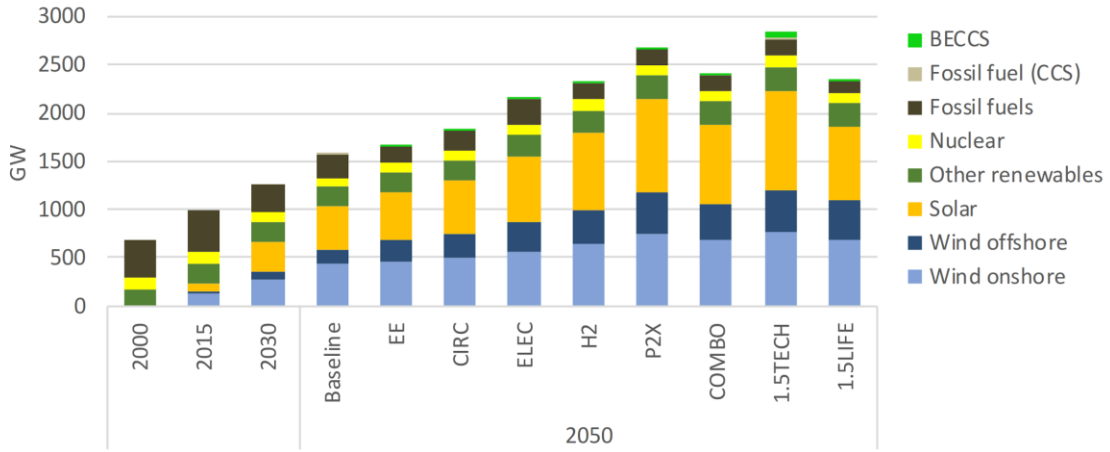
As might be expected, **electricity** plays a dominant role in the future energy system, supplying 41-53% of final energy demand in the scenarios modelled (see figure 20 above). Given the additional electricity demand in some scenarios for production of e-fuels and hydrogen, the Commission estimates that this could imply increases in gross electricity generation of nearly 200% compared to 2015 levels (see figure 22 below). The Commission notes that this represents an investment challenge, but also an opportunity for the development of economic activity and supply chains in Europe. The future electricity system is almost completely decarbonised, or even a source of negative emissions, with natural gas being the only fossil fuel left in the generation mix by 2050 (at a level of 1-5%). RES meanwhile make up 81-85%, with wind and solar alone making up 65-72%. Hydrogen is "only marginally used in power generation" and e-gas and e-liquids are virtually unused. Increased generation also implies dramatic increases in levels of installed capacity (see figure 24 below), particularly given the lower capacity factors associated with variable RES such as wind and solar.

Figure 22: Increase in gross electricity generation compared to 2015



Source: Eurostat (2015), PRIMES.

Figure 24: Power generation capacity



Source: Eurostat (2000, 2015), PRIMES.

The **electricity grid** is discussed at various points. The main focus, given the expected increase in electrification, is on the need for "reinforced and smarter electricity networks to make the best of the renewable resources allocation over the European territory". This to some extent, according to the Commission, means a more decentralised system, in which increasingly dispersed sources are matched with 'flexibility services' provided by consumers. And the Commission notes that "some long-term scenarios suggest that about 83% of EU households could be actively supporting the deployment of renewables" by providing such services or producing energy themselves. However the increase in sources such as offshore wind and the need to supply energy intensive industries with electricity will according to the Commision require the ongoing existence of "centralised elements".

There is very little discussion of the **gas grid**. The Commission suggests in several places that there would be benefits in using "existing gas transport infrastructure", which it claims without any basis "will still be operational in 2050", and even states that "there is clearly a rationale" for doing so, but without providing any cost-benefit analysis in support of that assertion. And while it suggests that the grid could cope with up to 15% (or in the future 20%) hydrogen by volume, it admits that an upgrade would be needed to accommodate higher levels of hydrogen and that "a renewed network" would likely be needed for pure hydrogen. Given the analysis presented elsewhere in the document that natural gas or other gases will predominantly be used in industry and power generation, and that in the 1.5LIFE scenario the use of all gases in the residential and services sector (meaning natural gas, hydrogen, e-gas, biogas and gas from waste) falls from 150 mtoe in 2015 to about 40 mtoe in 2050, it is far from clear that the gas distribution network - and by implication the transmission system - will remain economically viable. Rather than use precious biogas or e-gas for low grade heat in buildings, and suffer the "trade-offs" that the Commission suggests could result in the longer term from "managing simultaneously multiple networks", it may well prove more cost-effective to decommission the gas grid in urban areas and replace it with district heating (supplied by a range of low carbon sources including where possible by large scale

marine heat pumps). This in turn reinforces the need to ask serious questions about ongoing EU investment in additional gas infrastructure such as pipelines.

There is very little in this section on the question of **heat**, which given that it accounts for perhaps half of all energy use is a major failing. Curiously, the Commission notes in one place that distributed heat (largely district heating), which today accounts for only 10% final energy consumption for heat, could have the potential to meet 50% in future, including 25-30% using large scale heat pumps. But the results of the modelling, in contrast, show little change in the deployment of district heating compared to today's level. It's not clear why this is, but it may well be related to the well known technical difficulties of modelling district heating as opposed to individual building technologies. In general there are strong grounds for thinking that heat storage combined with district heating is likely to play a major role in decarbonising heating and cooling supply to buildings, particularly given the high costs associated with trying to solve the problem of peak demand for low grade heat, whether over daily, weekly or seasonal timescales, using a reinforced electricity grid and building level electric heating or a fully decarbonised gas distribution network.

Given the need to integrate high levels of variable renewables in the future decarbonised energy system, and the need for sector coupling, the Commission pays significant attention to the importance of **energy storage**, particularly the various forms of electricity storage, including in batteries (whether stationary or in electric vehicles) and through power to X, where X could be hydrogen, e-fuels or even ammonia. The Commission also mentions heat storage, for example in aquifers, but only very briefly, and as with discussion of heat more generally (see above) this appears to be a major gap in the analysis.

The Commission identifies a number of **enablers of the energy transition** (as part of "the paradigm shift to a the paradigm shift from electricity production following demand to a largely meteorologically driven production". Those highlighted include:

- Energy storage (see above)
- Better electricity interconnection - for example to connect offshore wind farms in the North Sea or solar energy from southern Europe. The Commission also mentions the possibility that High Voltage Direct Current connections could play a role in the establishment of a future "pan-European electricity super grid".
- Deeper demand response, with new tariff structures facilitating greater levels of consumer flexibility

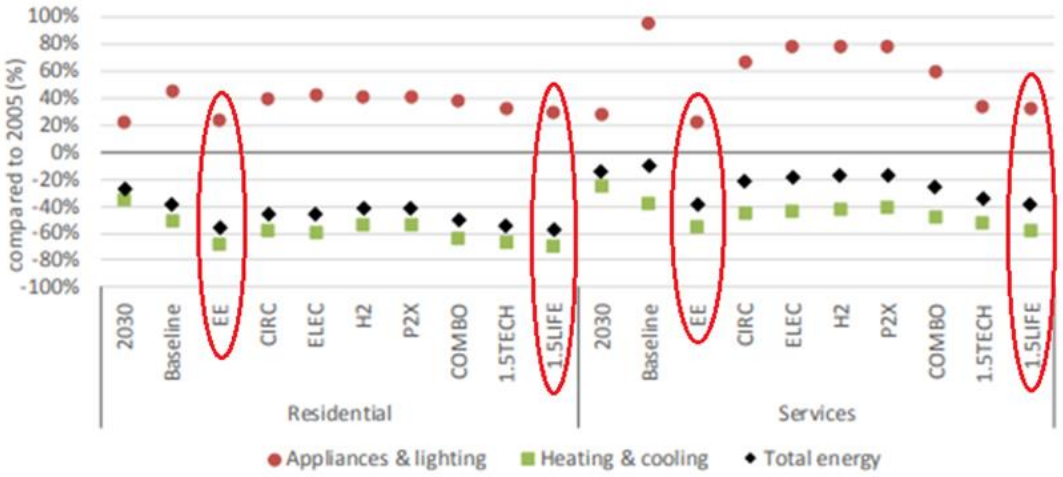
4.3 Buildings

The buildings sector has the highest final energy consumption of any sector in the EU and is therefore crucial to achieving full decarbonisation. Its emissions have however only been decreasing very slowly. The chapter lists a number of options for reducing emissions related to buildings:

- Improving the energy performance of the building envelope: Insulation is critical to reducing energy consumption in the buildings sector and associated GHG emissions. The biggest challenge for the EU is the renovation of the existing building stock; estimates show that up to 97% of the buildings built before 2010 will need to undergo some kind of renovation to comply with the net-zero emission objective (including deep renovation for the oldest and most inefficient).
- Efficient equipment: uptake of energy efficient equipment and appliances is a key driver for reducing energy demand. Ecodesign and Labelling Regulations have been particularly successful in setting performance standards for products, especially for lighting. However the efficiency of equipment for space heating and cooling deserves attention because there is still high, untapped energy savings potential.
- Fuel switching in heating and cooling: full decarbonisation of heating and cooling requires extensive penetration of renewable energy technologies. District heating and cooling systems, when efficient and decarbonised, have particular potential, considering their ability to provide storage and balancing services to the grid and help solve the problem of peak heat demand over various timescales.
- Smart buildings: digitalisation is shaping the transformation of the energy system and buildings will become considerably more integrated and connected with other sectors through the grid. ICT and automation technologies complement building insulation, facilitate the integration of renewables, improve demand side management and at the same time ensure comfort for occupants. Smart buildings also have a positive impact on the electrification of the transport sector.
- Near Zero Energy Buildings: the combination of all technological solutions will become the norm in the EU from January 2021.
- Societal and consumers choices: behaviour change has a significant role to play, in combination with smart appliances and other technological solutions, in the reduction and time optimisation of energy demand.

As regards the results of the Commission's analysis, the energy use in buildings varies considerably across the scenarios modelled, depending on whether pathways prioritise decarbonisation of supply or reduction of energy demand. For example the scenarios that focus on the deployment of alternative fuels (H2 and P2X) project much higher energy consumption in the building sector. In contrast, energy consumption in the building sector is projected to be lowest in the EE and 1.5LIFE scenarios (circled in red in Figure 39 below) which shows clearly that reducing energy consumption in the building sector is key to reaching zero net emissions in the EU as a whole. Under the Commission's most ambitious scenario, final energy demand in 2050 falls by 47% compared to 2005, but even this is likely to be a conservative estimate. The Coalition for Energy Savings has been working with research institutes to take an informed view of the issue and preliminary results seem to indicate that the EU could be more ambitious than the Commission suggests.[10]

Figure 39: Evolution of the energy consumption in buildings in 2050 (compared to 2005)



Note: "Heating and cooling" includes space heating, water heating, cooking and air cooling.
Source: Eurostat (total sectoral energy consumption in 2005), PRIMES.

In general the Commission presents a good picture of the challenges and opportunities of reducing energy demand in the buildings sector. However these issues are already well known and it is clear that without a concerted effort to put additional regulatory measures and financing instruments in place the available energy savings potential will not be tapped. What is also of concern is the suggestion that there is a trade off between energy efficiency and alternative fuels - with scenariost that focus on the latter projecting that energy consumption in the buildings sector will decrease at a slower rate. Reducing energy consumption in the building sector delivers additional benefits beyond emissions reductions, for example in terms of reduced energy poverty and improved living conditions for individuals and families, and should remain a priority even if other decarbonisation technologies are developed in parallel.

4.4 Transport

At just over 30 pages, the transport section of the SWD is relatively lengthy, but that is reasonable given that transport accounts for around a third of final energy consumption in the EU and that transport emissions have been rising rather than falling. And the Commission starts well, by saying that "an integrated system approach is required to put the transport sector on a sustainable path" and by setting out the many possible ways that emissions could be cut. For example the Commission notes that "stronger integration of transport with the energy system, with the support of ICT, is essential. Enabling smart charging for vehicle users, turning vehicles into multi-purpose assets, that generate cost savings for consumers and help the management of the energy transition, should be advanced quickly." The Commission also says lots of the right things on the "very large co-benefits [of decarbonisation] for pollution, noise, congestion and accidents, thereby improving the quality of life, especially in cities". But while the Commission identifies a wide range of options, from efficiency, internalising externalities (for example by road-pricing), modal shifts, electrification, video-conferencing and zero carbon fuels, its prescriptions appear rather passive in response. What is missing is any sense of urgency, or any serious engagement with the question of which technologies should actually be incentivised and how the required changes could be delivered.

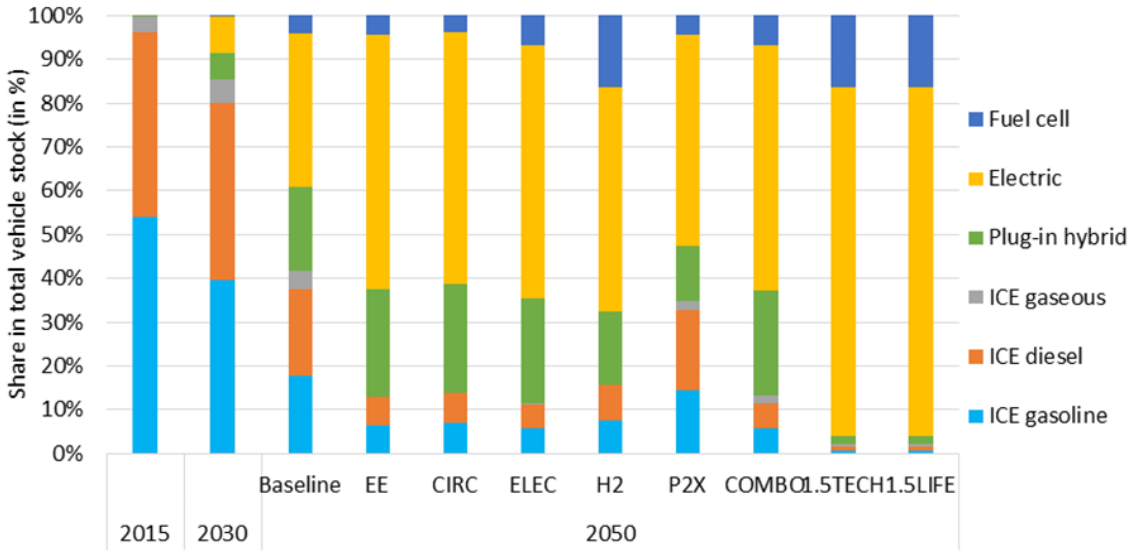
[10] https://www.isi.fraunhofer.de/en/competence-center/energiepolitik-energiemaerkte/projekte/energy-saving-scenarios-2050.html

On **cars, vans and buses**, the Commission reaches the - hardly surprising - conclusion that scenarios reaching zero net emissions mean the near-complete replacement of the internal combustion engined-fleet with battery electric vehicles (see figure 49 below - the results for light commercial vehicles look broadly similar). This will be accompanied (and facilitated) in the Commission's view by greater use of shared vehicles and "collective / public transport" (incidentally also reducing consumption of materials and hence industrial emissions). What is bizarre is that the Commission still seems to want to sit on the fence as regards technological options, saying only that "battery electric vehicles represent a promising option", and - without obvious justification - claiming that "it is however widely acknowledged that bridging solutions such as hybrids and plug-in hybrids would still be needed in the medium term". This latter claim seems unlikely given the rapid pace of development of fully electric vehicles and the fact that the Commission's modelling shows virtually no hybrid vehicles under a fully decarbonised scenario - and *all* new cars being zero emission from 2040 onwards.

Similarly, while the Commission's models of zero net emissions scenarios produce outputs in which fuel cell cars make up close to 20% of the fleet in 2050, it is questionable whether such a different technology - and the related supply infrastructure - would persist in such a minor role, particularly given that in the same scenarios, heavy goods vehicles using fuel cells only represent around 5% of the equivalent fleet. Cars running on green hydrogen rather than electricity would also require more than double the amount of renewable power generation to deliver the same service.

Finally, it is disappointing that the Commission devotes considerable space to a relatively uncritical discussion of studies from vested interests such as OPEC and the refining industry, which - unsurprisingly - conclude that there will be a big role for internal combustion engine cars and light goods vehicles. It seems highly unlikely from an objective perspective that the best use of precious and/or expensive biofuels and e-fuels will be in cars and vans, rather than harder to decarbonise sectors such as industry or aviation.

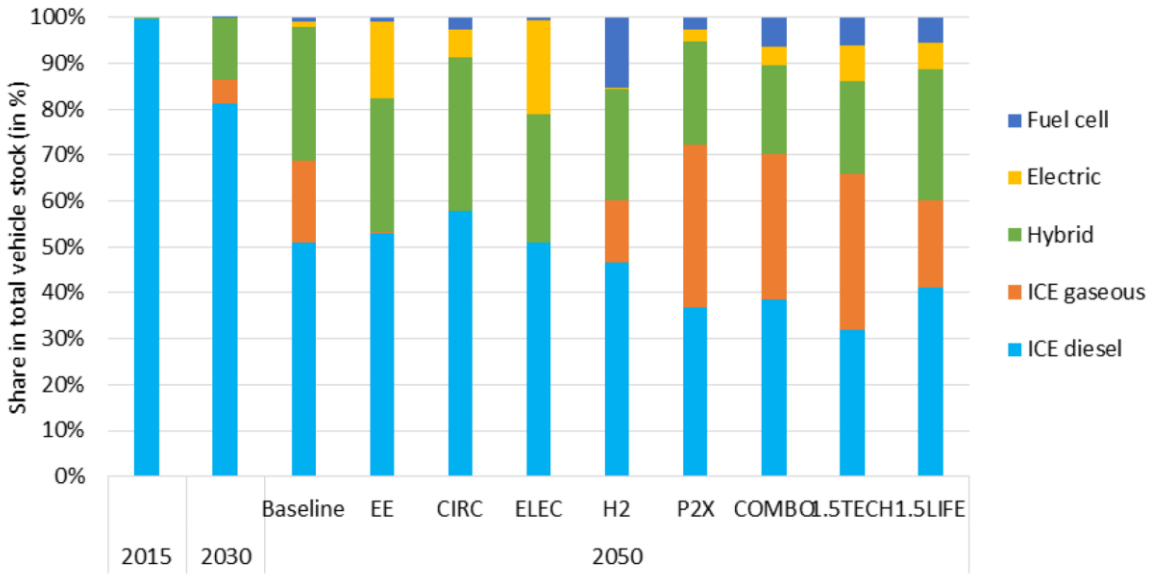
Figure 49: Shares in total cars stock by drivetrain technology in the Baseline and scenarios reaching -80% to net zero emissions by 2050



On **heavy goods vehicles** (meaning lorries, or, in American English, 'trucks') the Commission appears to be relatively sceptical of electrification, and assumes that a mix of different drive chains can be expected, including internal combustion engines (running on gas or diesel, from a mixture of fossil, bio and synthetic sources), hybrids, and, to a very limited extent, electric or fuel cell sources (see figure 51 below). This conclusion seems somewhat unlikely, requiring as it would the costly development and long term co-existence of multiple different fuelling or charging infrastructures across the European continent, including for liquid fuels, gaseous e-fuels, hydrogen, battery powered lorries and lorries reliant on pantographs and catenary lines. It also seems overly pessimistic on the potential of battery electric lorries, which are now under development by a large number of different manufacturers, including for long haul applications (e.g. the Tesla Semi). Transport & Environment has published some interesting peer-reviewed analysis on this subject[11] which is much more optimistic, as has Mckinsey[12].

[11] https://www.transportenvironment.org/publications/analysis-long-haul-battery-electric-trucks-eu
[12] https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/whats-sparking-electric-vehicle-adoption-in-the-truck-industry

Figure 51: Shares in total heavy goods vehicles stock by drivetrain technology in the Baseline and scenarios reaching -80% to net zero emissions by 2050



Source: PRIMES.

For **freight traffic** in general, and despite a significant shift to rail and inland navigation, driven by things such as road pricing, the Commission expects an increase in light and heavy goods vehicle activity in all scenarios. For example in the CIRC and 1.5LIFE scenarios road freight activity still increases by 37% overall despite a reduction of about 6% relative to the baseline. The Commission does not discuss the drivers of this growth or any options by which it might be constrained.

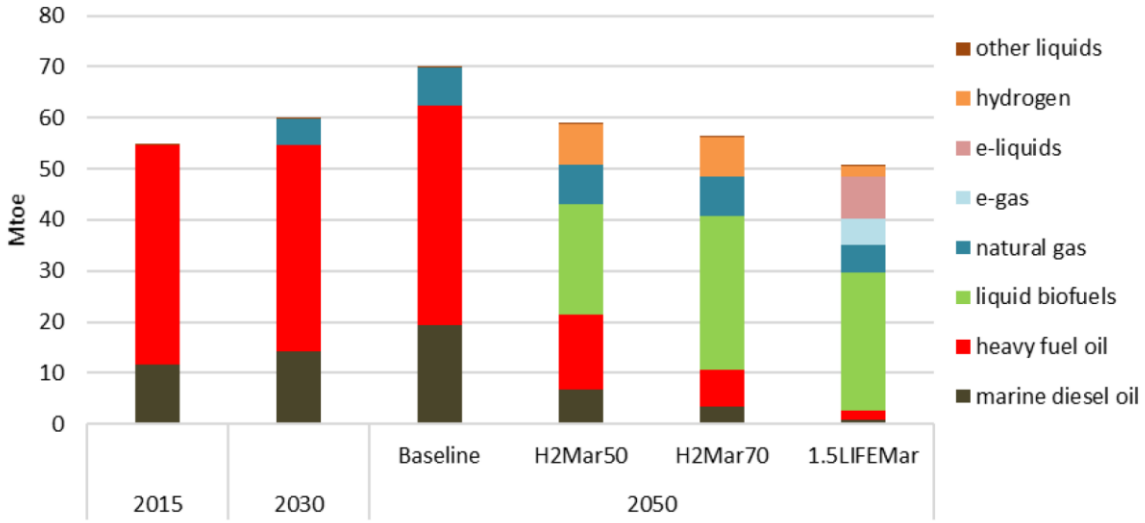
For **buses**, the Commission concludes that electrification would be the dominant technology in full decarbonisation scenarios, with a share of up to 88%. For **coaches**, which typically travel much longer distances, "the outcome is relatively similar to that for heavy goods vehicles, although fuel cells gain significant market shares in the 1.5TECH and 1.5LIFE scenarios".

As regards **rail transport**, both for passengers and freight, the Commission is surely correct that a "rapid capacity increase" is needed, and that electrification is the main decarbonisation option.

As regards **inland navigation** the Commission only projects very limited electrification, and even under the 1.5 scenarios, propulsion systems powered by liquid fuels maintain a dominant role (81-84% of the fleet), with the rest mainly being powered by gaseous fuels (13-16%). This result is at odds with recent technological developments in this sector, and indeed appears to contradict what the Commission says elsewhere in the document about electrification of short sea shipping and the examples it gives of existing demonstration projects.

For **international maritime** transport, which the Commission models separately, "activity at EU level" is expected to grow strongly over the 2015-2050 period, due to rising demand for primary resources and container shipping. Growth is limited somewhat under the decarbonisation scenarios due to reduced imports of fossil fuels for transport. As with inland freight, the Commission does not discuss the causes of increased demand or any options for constraining it. On decarbonisation options, and with a nod to history, the Commission notes that significant "gains can still be made through a radical rethink of vehicle and vessel design, including…the use of sails as an auxiliary power source in shipping." In the full decarbonisation scenario modelled, fossil fuels are replaced with a mixture of alternative fuels, in particular biofuels (see figure 54 below). But the Commission also cites an OECD study that envisages zero carbon shipping from 2035, primarily based on hydrogen and ammonia. Given the lower costs of such fuels compared to e-fuels and the many other demands on scarce biomass resources, it may be that such an approach would be a better long term solution. There are also very serious concerns as to whether the use of biofuels in shipping could ever effectively be policed: a big ship could refuel somewhere and then travel for months, making traceability and sustainability near impossible to ensure.

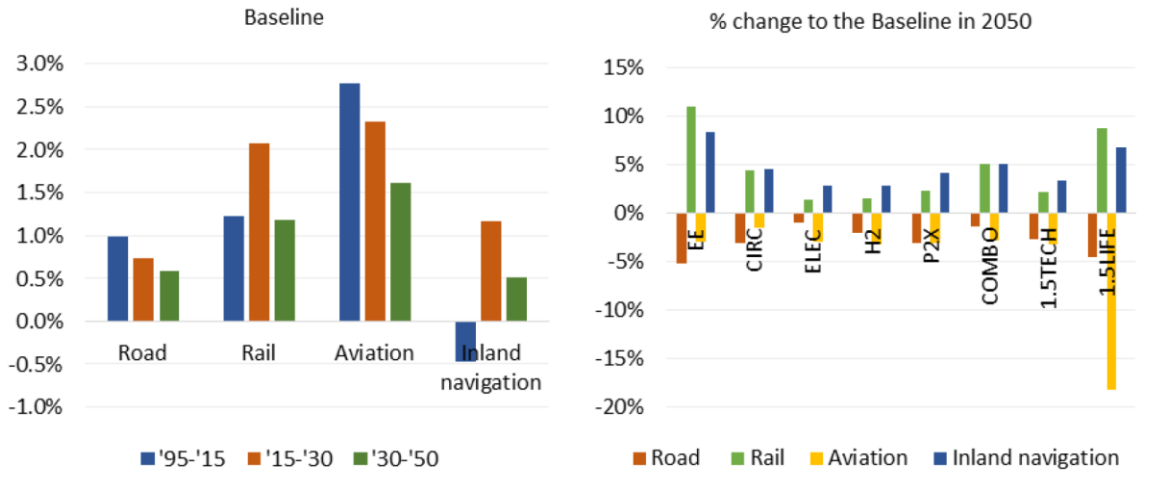
Figure 54: EU international maritime fuel mix in the Baseline and decarbonisation variants



Source: PRIMES.

Finally, on **aviation**, the Commission judges that from a decarbonisation perspective this will be "the biggest challenge, due to the projected growth in activity, and the fewer options available" and says that it will require "a multi-pronged approach." Part of the solution envisaged by the Commission is to restrict the growth in demand compared to the baseline. That baseline would see "overall, aviation activity including international extra-EU flights…go up by…101% by 2050, saturating European skies and airports." Demand growth could in the Commission's view be constrained by shifting intra-EU air trips taken for leisure and personal reasons to rail and coaches, a reduction in the distance travelled for extra-EU trips and a reduction in the number of business – trips thanks to the adoption of video/teleconferencing facilities. But as the Commission says, "no explicit policy instrument that would steer change in people's behaviour has been specified: it could be interpreted as due to rising environmental awareness, or take place in combination with strong policies." The change relative to the baseline is also only significant in the 1.5LIFE scenario (see figure 45 below) and even in that case demand would still expand - by 59% for intra-EU and 70% for extra-EU travel over the 2015-2050 period.

Figure 45: Passenger transport activity in the Baseline (average growth rates per year) and in the -80% to net zero scenarios (% changes to the Baseline in 2050)[318]

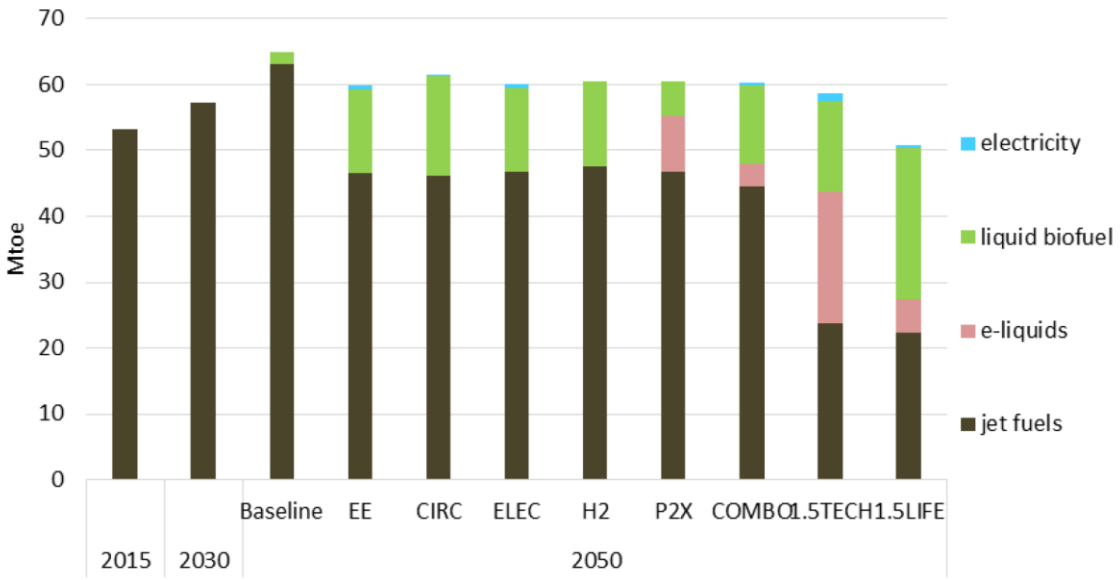


Source: PRIMES.

As regards decarbonisation options, the Commission appears relatively sceptical of electrification, saying that "full electric aircraft are being developed, and the first small non-commercial planes are operating, but the potential for large full electric aircraft is yet untested and remains in an exploratory phase". It does later note, however, that some developments are ongoing, including on hybrid electric aircraft. The main decarbonisation option presented - in addition to reduced demand and increased aircraft efficiency - is therefore the substitution of the fossil jet fuel used in aviation with biofuels and e-fuels, although even in full decarbonisation scenarios a significant share of fossil fuel remains (see figure 52 below). In the short to medium term, given fleet renewal timescales and the nature of existing ground infrastructure, the Commission is probably right that biofuels and e-fuels are the most likely option. However they are likely to prove only to be transitional to a cleaner long term solution.

On this note it is disappointing that there is no mention of liquid hydrogen fuelled aircraft. The EU co-funded a project involving Airbus on this topic nearly 20 years ago, called CRYOPLANE, which concluded that liquid hydrogen would be a suitable fuel for long and short haul aviation and that hydrogen aircraft would be cleaner and have lower climate impacts (e.g. due to NO_x emissions etc) than those using (carbon-based) e-fuels or biofuels. Given the costs of direct air capture of CO_2, the other demands on limited supplies of biomass (notably the organic chemical industry, which by definition cannot be decarbonised) and the difficulties of restraining growth in air travel, the use of liquid hydrogen in aviation may well be the best long term solution. This is also an area in which the EU could still become the world leader and monopolise the relevant intellectual property. But to do so it would need to start now: as the Commission itself notes, the relatively long replacement time of the vessel/aircraft fleet in these sectors imply high risk if regulatory action is delayed. Especially in the aviation sector, the technological challenges are large."

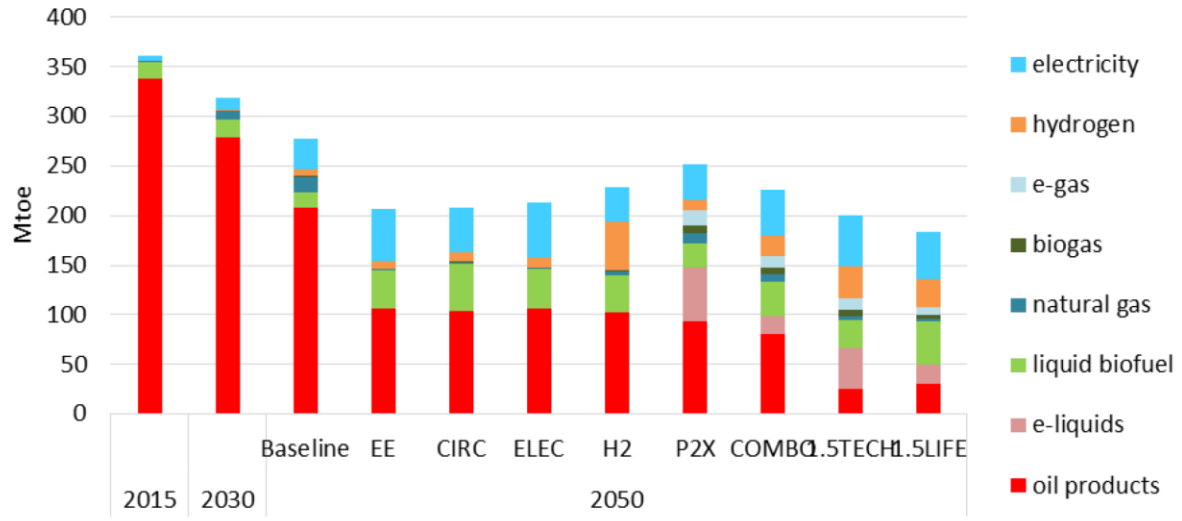
Figure 52: Aviation fuels mix in the Baseline and scenarios reaching -80% to net zero emissions by 2050 in 2050



Source: PRIMES.

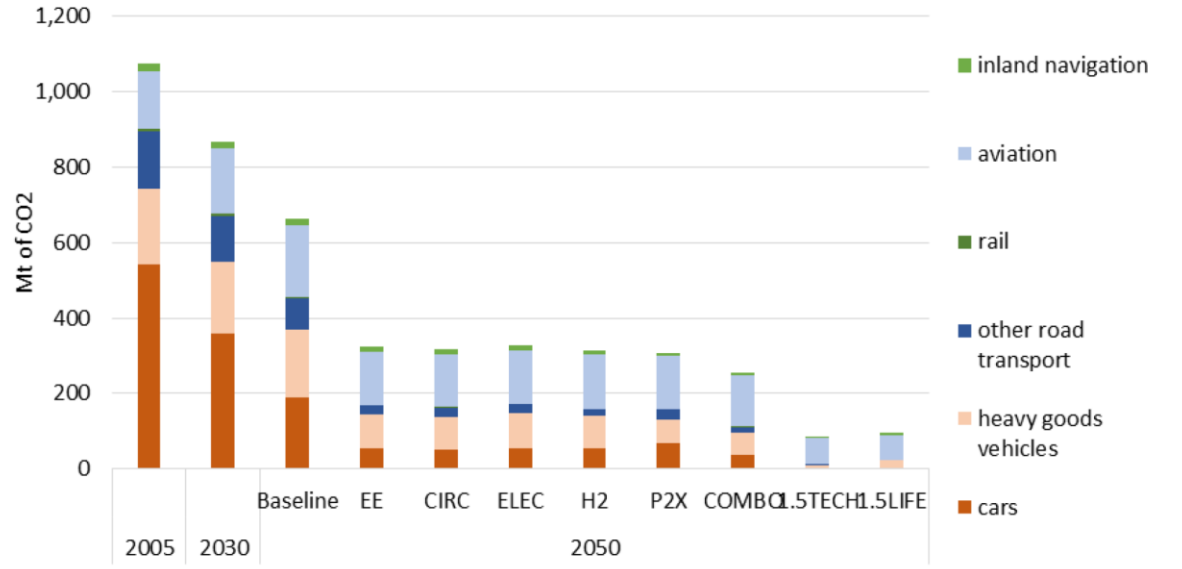
In terms of **overall fuel use and GHG emissions**, the Commission's analysis suggests that full decarbonisation of the transport sector involves a very significant reduction in demand compared to the baseline, and the replacement of oil products with a range of alternatives (see figure 57 below). The areas that look troubling from an environmental perspective are the extensive reliance on biofuels (which are unlikely to be available in the quantities imagined - see later sections) and natural gas. Given the need for complete decarbonisation of the transport sector at some point in future the Commission should have assessed more ambitious scenarios, both to limit the extent of negative emissions required and to promote first mover advantage for EU companies. The figures on emissions (figure 58) also highlight the extent to which aviation remains a problem under all scenarios, accounting for the majority of remaining transport emissions under any decarbonisation scenario.

Figure 57: Fuels consumed in the transport sector in 2050



Source: PRIMES.

Figure 58: CO_2 emissions from transport in 2050 (in $MtCO_2$)[342]



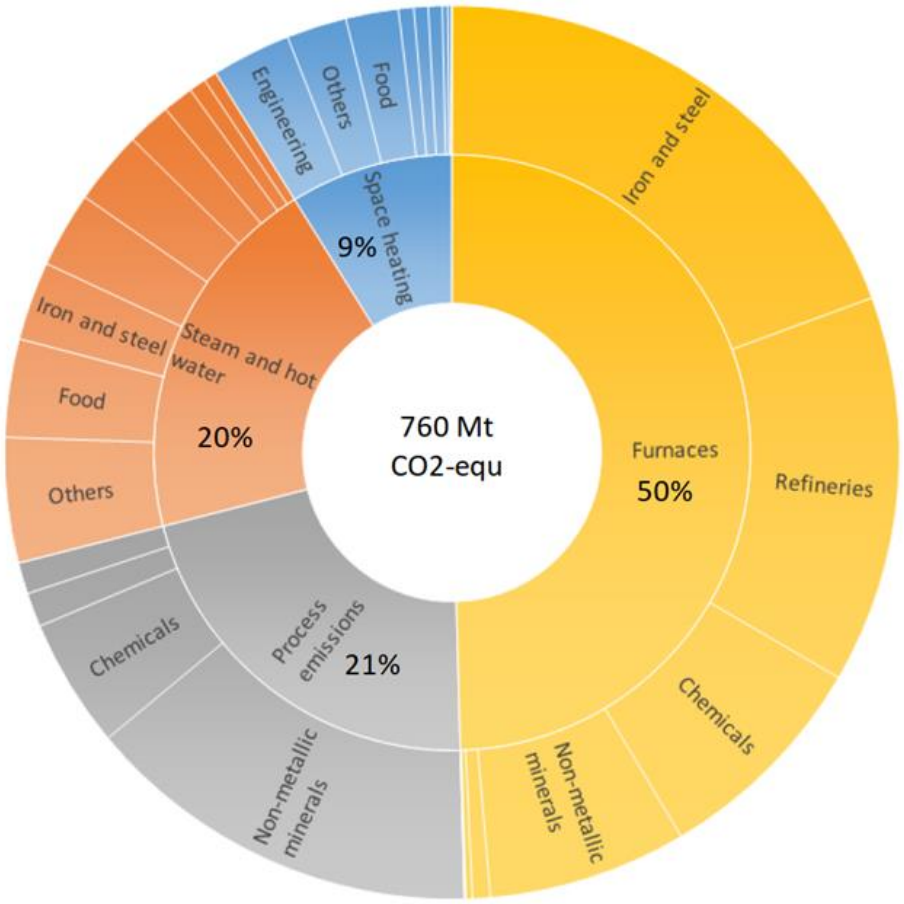
Source: PRIMES.

In several places in this section there are references to **societal and consumer choices**. As the Commission says, "consumer choices influence much of transport development [as] In the end, it is the consumer who decides. But consumer choices are strongly influenced by government policies and business offerings." It is welcome that the Commission argues that "in terms of future policy design by governments, internalising the externalities of transport through road charging would increase social welfare. Enhanced implementation of the user/polluter pays principle and public incentives, including subsidies, would make sustainable infrastructure and greening of assets financially viable and promote modal shift." In what sounds as though it could in part be a reference to air travel, which is seriously under-taxed, the Commission also says that "to level the playing field between different transport modes, external costs would need to be internalised in all of them. In addition, dynamic pricing could reduce congestion in both road and rail transport with positive effects on CO_2 emissions."

4.5 Industry

The Commission essentially essentially dismisses the issue of 'imported' or 'embedded' emissions, whether in relation to food or products. This is disappointing, because while accounting of emissions under the UNFCCC is done at source, there is no solution to climate change that does not involve action to reduce EU imports of goods that drive high emissions - notably through deforestation - elsewhere in the world.

Figure 64: EU 28 Industrial direct emissions by end use and sub-sector



Source: FORECAST.

The strategy is good on the need for "putting **industrial modernisation** at the centre of a **fully circular economy**" and the need for the full decarbonisation of resource and energy intensive industries in Europe. The Commission describes this transition as the 'next industrial revolution' and 'the circular industrial transformation' – nice catch-phrases. The analysis accompanying the strategy shows vast opportunities exist now in high-emitting sectors such as steel, cement and chemicals to deliver a transition to zero-carbon through circularity, investment in energy saving, renewable energy and breakthrough clean technologies. This is an important shift in mindset and the Commission should intensify work to deliver a climate-proof industrial strategy and policy framework.

The key priority areas for action to deliver a climate neutral industrial sector are in line with WWF thinking and framing of the transition required in Energy Intensive Industries (EIIs). Of the seven priorities described in the 25-page Communication, the following are particularly relevant and are covered throughout this section:

- Priority no 2, i.e. maximise **deployment of renewable energy t**o fully decarbonise energy supply in EU. Up to 2.5 times more total electricity generation will be needed in 2050 compared to today.
- Priority no. 4, meaning a competitive EU industrial sector where the **circular economy** is a key enabler both of GHG emission reductions and reliable supply of the raw materials essential to new technologies. The Commission rightly highlights the need for a system which uses materials and products more efficiently to decarbonise the EIIs, including through material switching in some sectors, and says that EIIs have 10-15 years to demonstrate new technologies at scale.
- Priority no 7, which relates to tackling remaining industrial/process related CO_2 emissions with **CCS**. The Commission discussed the difficulty of completely eliminating process emissions and the consequent need for CCU/CCS, which it presents as a necessary abatement option for EII's, alongside

hydrogen use. This will require new CO_2 infrastructure both for transport and storage, and the policy framework to go with it.

The staff working document lays out the CO_2 emission reduction potentials in resource and energy intensive sectors, as well as investment and innovation requirements. Recognised technological solutions for industry included in the modelling are:

- Energy efficiency, (renewable) electrification and fuel switching
- Innovative low carbon processes
- Carbon capture and sequestration and/or use (CCS and CCU)
- Resource efficiency/circular economy
- Industrial symbiosis
- Material substitution (especially in the cement sector).

The document assumes that a continuation of current efforts and policies in industry could achieve additional GHG emissions reduction by 2050, ranging from between 55%-65% compared to 1990. Furthermore, the strategy assumes it will not be possible to reduce industrial emissions by 80% to 95% with currently commercialised technologies alone. That said, and although there is no widely accepted pathway for achieving deep reductions in industrial sector emissions, solutions do seem to exist. To contribute to reaching zero net emissions overall (meaning reductions in emissions of around 95%) all necessary approaches and technologies will need to be deployed in the industry sector, including CCS and CCU to deal with emissions from sectors that are hardest to decarbonise, notably cement and chemicals.

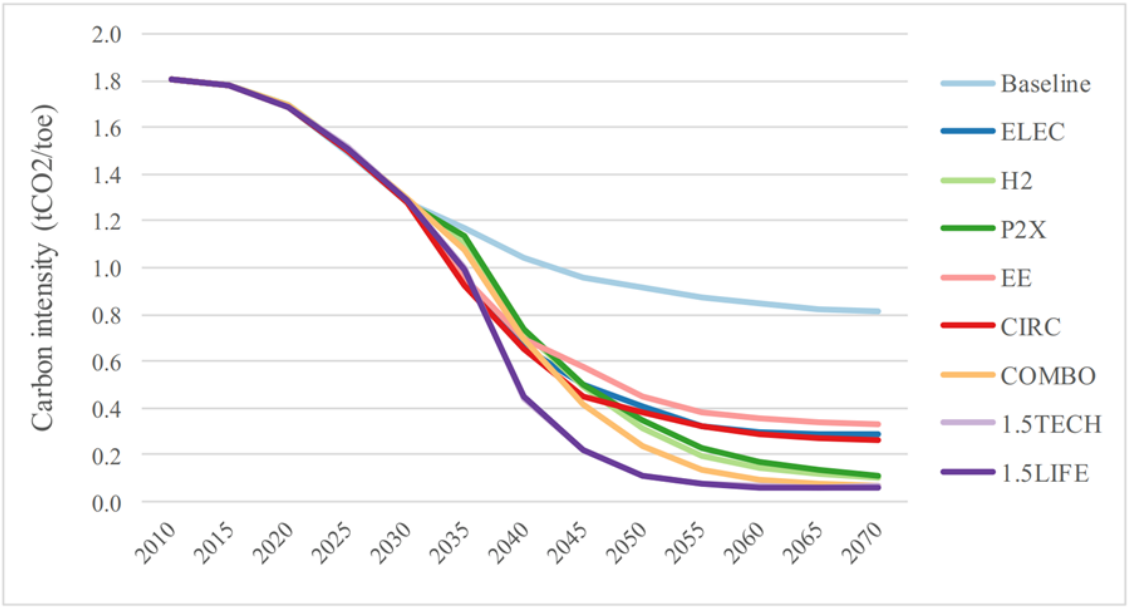
Contrary to the other sectors, the modelling of industry sectors is done using two models: Primes and Forecast. Scenarios involving 80% reductions in EU emissions and combined scenarios (95%) are presented, delivering similar results. In Primes, total final energy consumption in industry is projected to decrease between 2015 and 2050 in all scenarios, despite the projected increase in industrial output overall. The highest reductions (between 22-31%) are observed in the scenarios with increased energy efficiency and/or circular economy principles.

In 80% scenarios, CCS installations appear in 2045 capturing 30 $MtCO_2$, while post-2050 the amount of CO_2 captured increases to 135 Mt. In the circularity scenario, due to reduced industrial output of carbon intensive industries, only 44 $MtCO_2$ are captured in 2050, with increasing trends thereafter being similar to in the other scenarios.

The “most ambitious” scenario in the Forecast model achieves a 95% GHG reduction compared to 1990 overall, but even here there are process emissions left in the industry sector and it assumes some ongoing use of fossil fuels in 2050. Estimates of electricity needs in industry vary depending on the model and scenario: Forecast modelling assumes the need for about 3,000 TWh of electricity for the EIIs alone, and Primes 4,808 TWh. This is in the same range as calculations by Eurelectric and IES-VUB.

The Commission concludes from its analysis that Paris-compatible heavy industry is feasible (mostly here referring to 95% reduction) but that this will require comprehensive action.

Figure 70: Carbon intensity in industry



Source: PRIMES.

As noted above, the strategy does not propose to increase the EU 2030 targets to align them with the required 2050 ambition. Nor does it propose new policies or lay out a policy agenda to reach the suggested goal. Industry associations meanwhile are all calling for exactly such an industrial policy agenda, but without committing to a specific target or ambition level. One crucial goal for the coming months will be to join up the two positions, meaning clear and ambitious goals in combination with a new policy framework that will deliver them, and that will ensure a competitive, carbon neutral EU industrial sector for the future.

4.6 Non-CO_2 emitting sectors

While it is not in its title, most of this section is focused on **agriculture**, as it accounts for at least half of the non-CO_2 emissions across the economy. Methane (CH_4) and Nitrous Oxide (N_2O) make up the majority of those, at 55% and 32% respectively (in 2015). The rest is mostly various fluorinated gases from air conditioning and refrigeration.

In emissions terms, agriculture has benefited inadvertently from certain changes in the past (e.g. the reduction in farm animals in Central and Eastern European countries following their accession to the EU) but as the Commission highlights there is a high risk of stagnation in further emissions reduction. As the document underlines, agricultural emissions cannot fully be eliminated, but they must nevertheless be reduced in order to minimise the need for carbon dioxide removal. Even in the '1.5LIFE' scenario, which sees agricultural non-CO_2 emissions nearly halve, they make up most of remaining EU emissions in 2050.

Unfortunately, support from the **CAP** to cut GHG emissions from agriculture has been almost nonexistent to date. Climate-mitigation rationale already features in the CAP, but hardly any CAP measures have been targeted or effectively implemented in this area. Overall, the CAP continues to be a policy that largely supports the livestock sector (either directly or through support to crops used for feed), without effectively incentivising the sector to be closely integrated with crop agriculture and/or the grazing land available. This has enhanced the dependence on imported feedstock and high GHG emissions, without any of the environmental benefits related to low-input, high nature value pasture management. As regards crop agriculture, measures targeting carbon stocks in soils (e.g., low tillage) and biomass (e.g., agroforestry), or genuinely reducing sources of emissions such as those originating in synthetic nitrogen fertilization, have been very limited in both scope and uptake. Some partial successes exist (for example CAP support for maintaining hedgerows), but do not go far beyond maintaining existing best practice on farmland.

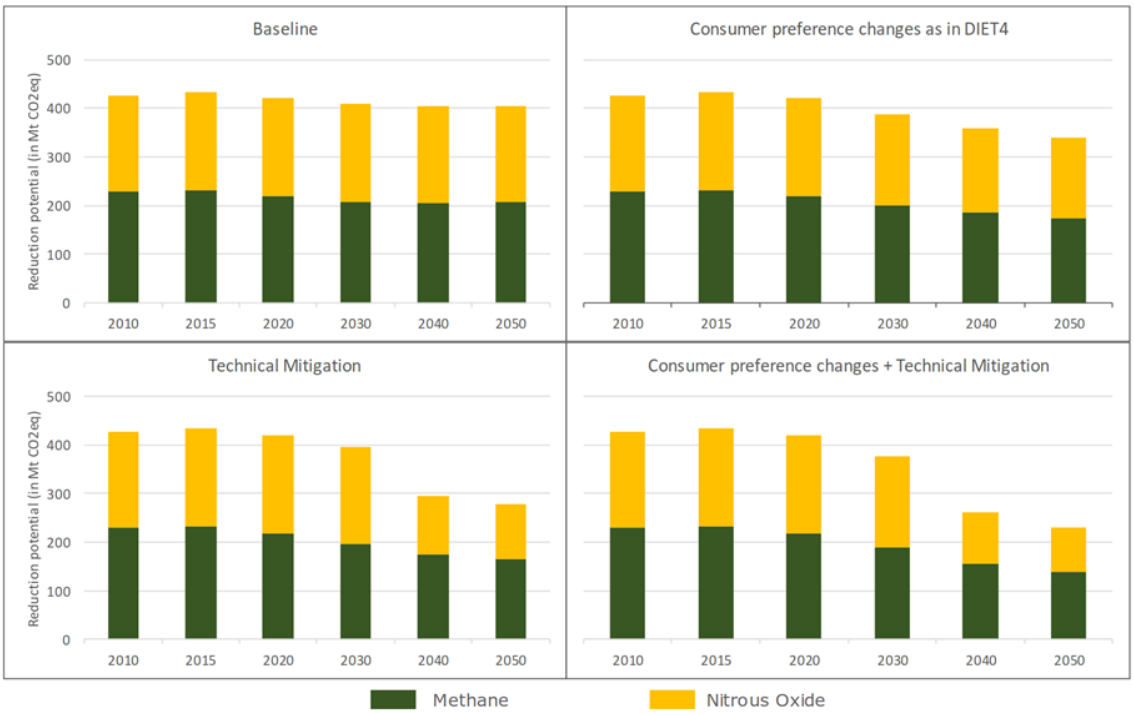
As regards **supply-side** decarbonisation strategies, increasing productivity and adopting innovative technology are the two options highlighted by the Commission, which is very much in line with the intensification of agriculture we have witnessed over the last few decades. Examples suggested include ways of tackling enteric fermentation in ruminants (e.g. higher productivity per animal, selection of animals and feed mixes to reduce methane emissions), using anaerobic digestion of manure to generate biogas under controlled conditions (rather than leaving it to emit methane freely), and reducing emissions from soils (mainly by improving fertiliser application and using nitrification inhibitors, but also by leaving soils with high organic content fallow).

As regards livestock farming such options are clearly only applicable for indoor operations, and not for extensive conditions where productivity per animal tends to be lower and manure is not collected. But extensive grazing of animals is generally a more desirable option, due to the ancillary benefits it generates (better animal welfare, the maintainance of biological and landscape diversity, low-input food production, etc.). And while highly productive and concentrated indoor livestock operations may be "climate-efficient" per kg of product, they cause multiple other problems, including increased demand for soy and other agricultural commodities as feed (driving deforestation), local air and water pollution due to the high density of animals, the lack of integration with crop agriculture, and animal welfare and public health concerns (e.g. relating to the use of antibiotics). The Commission strategy lacks any analysis of these issues or the appropriate role of grazing land as part of an integrated, climate-friendly food system.

Demand-side approaches (essentially reduced consumption of animal products and a reduction in food waste) are briefly mentioned. All scenarios analysed include the same critical reduction in food waste (50%, consistent with SDG12.3), but varying shifts in diets; for presumably political reasons, these are described as "sensitivity analyses" to "understand the possible implications of differing trends in consumer preferences". Diets have already been changing: overall meat consumption in the EU reached a plateau in the 1990s and since then there has also been a shift in the type of meat consumed, with beef consumption down by one third but offset by a similar increase in poultry meat consumption. The potential to use more aquaculture (with some analyses showing it to be more efficient than land-based livestock farming) is also mentioned by the Commission.

The most ambitious scenario in terms of dietary shifts (which involves a fall of approximately 35% in the level of calories derived from livestock) could by 2050 deliver a reduction of 25% in emissions from agriculture (compared to 2015) and by 2070 a reduction of 44%. 25% is of a similar scale to the potential supply side emissions reductions, meaning that together such approaches would by 2050 almost halve emissions from agriculture (see figure 78 below), assuming the volumes of animal products not consumed in the EU are not simply exported instead. The analysis therefore highlights the dramatic impact of red meat and dairy consumption on emissions, and Member States should consider seriously in preparing their long term strategies how consumers might be encouraged to adopt healthier diets.

Figure 78: Example of reduction potential in the agriculture



Source: GAINS.

On this note it is worrying that the Commission raises the question of 'carbon leakage'. While a reduction in livestock farming emissions should indeed be driven by demand side changes rather than by penalising farmers, carbon leakage is often used as an excuse for maintaining or even increasing high intensity "export-oriented agriculture" without accepting that the economic beneficiaries take responsibility for the resulting emissions. Such arguments also disregard issues relating to social justice, North-South equity or food sovereignty, and the other negative impacts associated with high intensity agriculture.

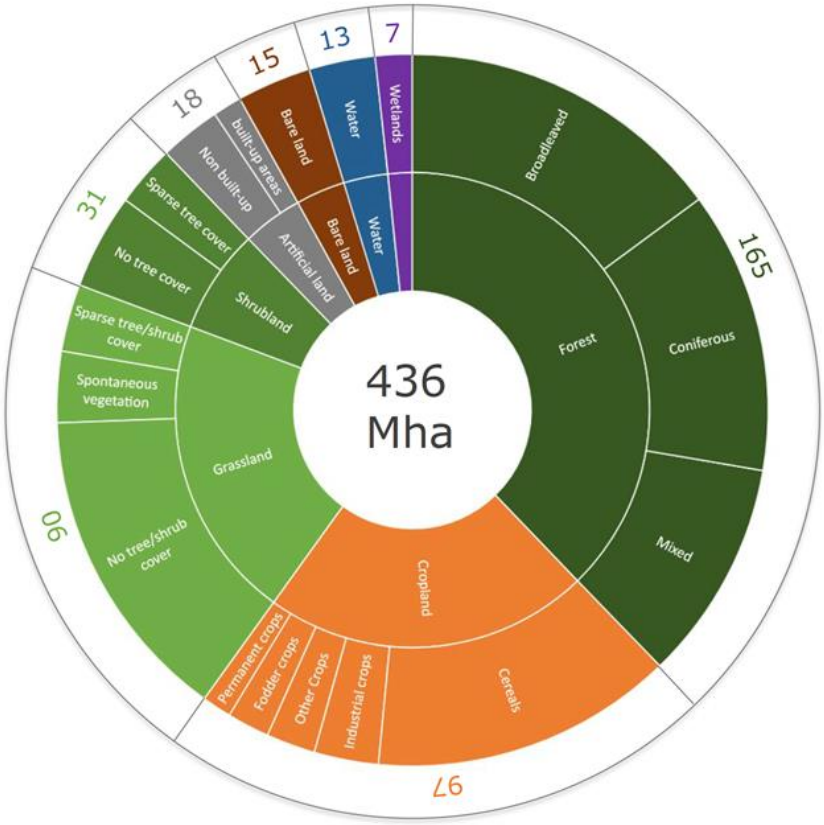
Beyond agriculture, the chapter highlights that significant reductions can also be achieved in other non-CO_2 emitting sectors, for example in waste management, energy and transport (for methane and nitrous oxide) and in industry (for nitrous oxide and fluorinated gases). The conclusions point to the need to develop the right policy tools, such as an EU strategic plan for methane, covering agriculture, waste and fugitive emissions in the energy sector, to ensure potential emission reductions are realised by 2050.

The chapter closes by listing some of the synergies related to the action described, to wit: reducing fossil fuel consumption will reduce fugitive emissions of methane, the anaerobic digestion of manure can produce renewable energy, and improving fertilisation can not only reduce emissions but also prevent nitrate pollution.

4.7 Land resources

This critical section of the document - and perhaps the one most connected to broader ecological interests - is also the weakest. It contains some sensible statements - for example that "land is a precious and finite resource" - but also some fundamental errors, and its conclusions are based on modelling assumptions that are known to be wrong. To a greater extent than other sections it appears to have been drafted by committee, with the tensions between climate, energy, agricultural and ecological interests clearly visible in the final text.

Figure 81: Land cover overview in 2015



Source: Eurostat.

As regards the (perhaps less contentious) issue of **agricultural soils**, the Commission's analysis is compelling and deserves strong support. Firstly, it notes that there are significant 'win wins' from practices such as agroforestry and conservation agriculture, which both increase carbon sequestration in soils and landscapes and also provide numerous other benefits, notably soil fertility, productivity, water retention, prevention of soil erosion, nutrient retention and biodiversity.

Secondly, it makes clear that preserving carbon in "organic soils" (i.e., those with a top layer with high organic matter content, such as peatlands, and which hold 30% of the world's soil carbon in just 3% of the global land area) should be a top priority. In Europe only 1.5% of cropland consists of organic soils but those areas account for 55% of total cropland soil emissions. Even more strikingly, the 3% of grassland on organic soils emits as much carbon as is sequestered by the remaining 97% of grassland on mineral soils. Options for addressing this include rewetting the soils of such peatlands and wetlands and potentially limiting agricultural use (e.g. through paludiculture). Modifying the way these types of land are used, for example by incentivising the management

options that reduce emissions most effectively, would likely be a very cost-effective approach to reducing emissions in the agriculture sector.

Thirdly, as regards mineral soils, while noting that there are significant uncertainties as to the data and without offering any specific numbers, the Commission notes that standard practices to build up organic matter and prevent its oxidation (reduced till, cover crops or leaving crop residues on site) could both enhance carbon sequestration in agriculture and increase net primary productivity.

Where the Commission goes wrong is in advocating a huge increase in **energy crops**, meaning the cultivation of switchgrass, miscanthus or short rotation coppice, on up to 10% of current productive agricultural land, for the purposes of providing (via gasification and pyrolysis) biogas and biofuels. This is based on a fundamental error in the Globiom model used by the Commission's consultants, which assumes that large areas of unused or abandoned land are available at essentially no opportunity cost - meaning that they sequester no carbon at present but nevertheless would generate high yields of biomass if used for energy crops. As studies make clear, reforestation, or simply allowing land to revert to forest over time, typically delivers significantly higher net GHG impacts than using such land to produce energy crops[13]. This mistake, discussed further below in relation to negative emissions, contradicts arguments elsewhere in this section about the need to increase afforestation on abandoned land and also has implications for the Commission's conclusions on the use of land to provide feedstocks for products, where these are short-lived and subsequently burnt for energy.

As regards **forest biomass**, the Commission notes that the EU's forests are currently a net carbon sink of around 400 $MtCO_2$ and have been stable at that level since 1990. The fact that EU forests are a net sink - the result of their slowly recovering from centuries of overharvesting, not least for fuel - is very welcome. But this misses important points. One is the quality of the sink, i.e. whether the forest is biodiverse and provides other significant ecosystem services: biodiverse forests composed of native tree species are more likely to provide rich and resilient carbon storage. It is also a generalisation, as the EU-wide numbers mask the fact that there are forests that are very intensively managed compared to others (for example because some are protected or currently unexploited). The Commission also makes the mistake of thinking that the sustainability of any particular biomass feedstock from a climate perspective is related to the "net annual increment of the forest", when in fact it depends primarily on what feedstock is being burnt.

More importantly, increased harvesting of forests for energy is likely to increase emissions compared to fossil fuels for decades to centuries. Warnings along these lines and a call for the EU to limit incentives to wastes and residues were made in a letter to EU lawmakers in 2018 signed by nearly 800 scientists, including multiple IPCC lead authors and winners of the US National Medal of Science and Nobel Prize[14]. However for reasons that are not clear the climate and energy Commissioner Miguel Arias Cañete personally advised MEPs to vote against the amendment that would have done this, saying that it was not 'environmentally desirable'. The new Renewable Energy Directive therefore contains no restrictions at all on the types of forest biomass that can be burnt with subsidy and counted as carbon neutral. It is likely that the EU will be forced to perform a U-turn on this issue in the near future, as in its current form the Directive poses a serious threat to the global climate and forests.

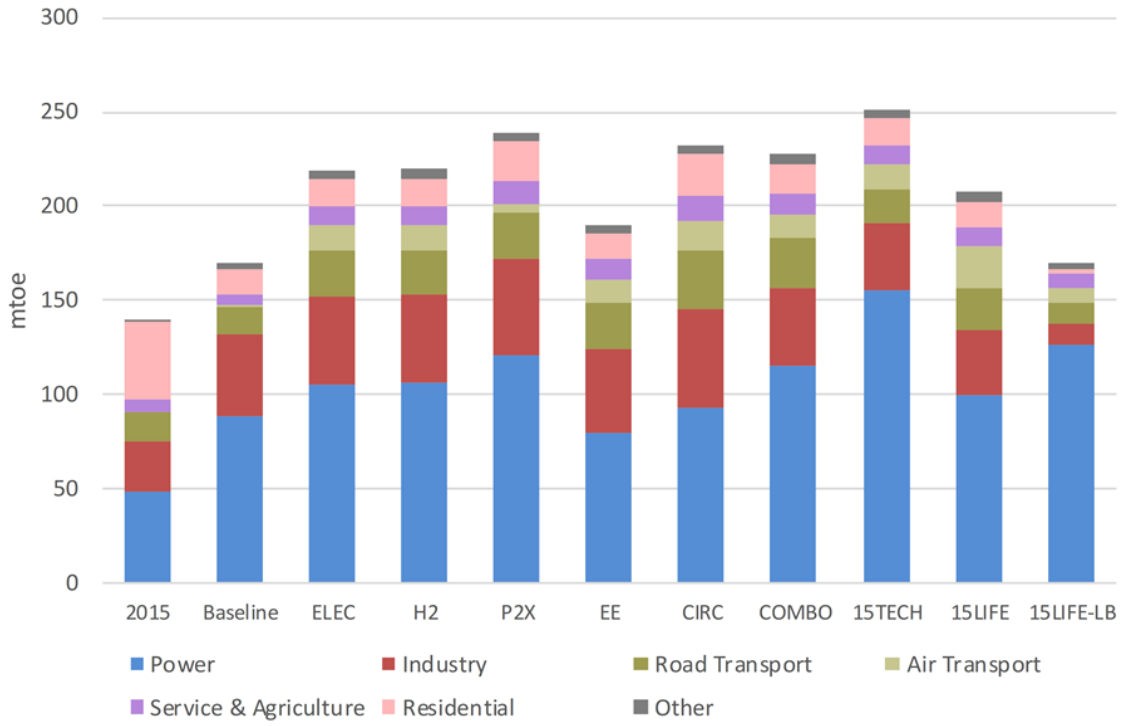
In the long term strategy the Commission already seems to be backtracking somewhat, making clear that biomass extraction affects both forest carbon stocks and sinks, and assuming in its scenarios no significant increase in the burning of 'stemwood' (tree trunks) and no big increase in the level of imported biomass. While this slight shift in position is welcome, the rapid increases in biomass imports in recent years and the lack of any meaningful sustainability critreria in the Renewable Energy Directive mean this is far from a safe assumption, and it is alarming that the Commission says that "no assessment has been made on the overall climate impacts if biomass were to be imported instead [of being supplied domestically]". The Commission also provides no assessment of how the dramatic increases in the extraction of forest harvest residues is to be achieved and what the impacts of that would be on soil carbon, emissions, biodiversity or soil fertility (and hence the rates of re-growth and future carbon sequestration). It seems clear that the Commission will need to perform a U-turn on the issue of forest bioenergy in the near future, and amend the Renewable Energy Directive to exclude from incentives those types of forest biomass that increase emissions compared to fossil fuels.

It is welcome that the Commission recognises the potential for restoration of forests and reforestation to deliver not just climate benefits but also significant co-benefits, including reduced risks of soil erosion, flood protection and biodiversity protection. However the analysis on the use of forest (or agricultural) biomass to substitute other materials, the circumstances in which this would deliver climate benefits, and the 'harvest optimisation' or other forest management practices that may or may not make sense in this context, is thin, and largely unreferenced. In places the Commission appears to fall into the trap of arguing that trees need to be cut down to stimulate the carbon sink and ensure that forests continue to sequester carbon, without adequately questioning the impact this has on carbon stocks in the forest or the 'technosphere', or indeed setting out how "active sustainable management of forests" would be defined.

[13] http://d2ouvy59p0dg6k.cloudfront.net/downloads/eu_bioenergy_policy___wwf_briefing_paper___final_4.pdf

[14] https://www.dropbox.com/sh/sqhn0b4h6dwvq65/AADnK8Q18AAFaCeWvbZ40vFGa?dl=0&preview=UPDATE+800+signatures_Scientist+Letter+on+EU+Forest+Biomass.pdf

Figure 83: Use of bioenergy by sectors and by scenario in 2050

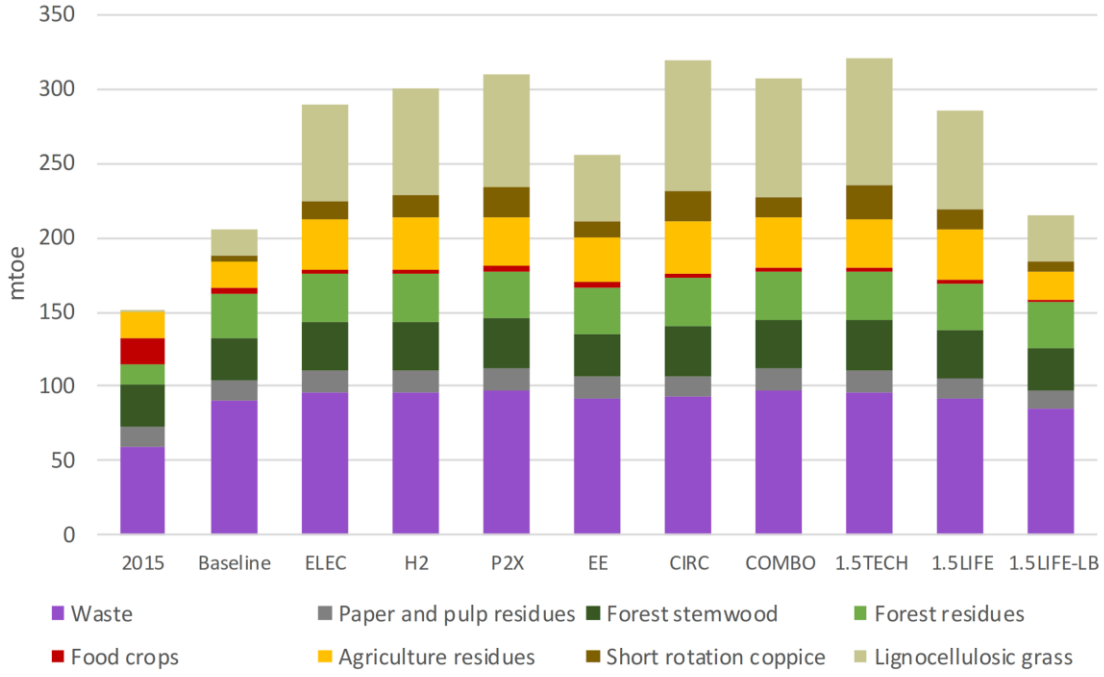


These deficiencies reinforce the need for further work by the Commission in the coming months to ensure that the use of forest biomass for climate purposes is addressed in a thorough manner. This includes looking at the impact on climate, biodiversity and nature, changing the (currently meaningless) sustainability criteria for forest biomass in the revised Renewable Energy Directive and ensuring that nature laws such as the Birds and Habitats directive are fully applied. Illegal logging is a problem even within the EU, so a strict enforcement of the EU Timber Regulation in all EU Member States is also essential. A common agreement on measurable indicators for sustainable forest management from a social, economic and environmental perspective, according to forest type, though in no way a substitute for excluding high risk feedstocks on climate grounds, would also help to assess the quality of sustainable forest management across the EU.

Overall, as regards biomass, the Commission's modelled scenarios pose more questions than answers, which perhaps explains why the Commission felt the need to carry out sensitivity analysis on this point - effectively generating a ninth 'low-biomass' scenario based on the eighth '1.5LIFE' version. For example the fact that so much biomass is used in power generation rather than transport - for example up to 75% in the 1.5LIFE low biomass variation (see figure 83 above) - is perplexing, as is how the foreseen reduction in residential biomass (in the form of biogas) fits with the long term existence of the gas distribution network, and hence the gas grid as a whole. While use of bioenergy is projected in some scenarios to more than double (see figure 84 below), the role of biomass and land use in relation to climate change mitigation appears to be a significant gap in the overall strategy, as is the lack of detail on which biomass feedstocks are used and for what purpose[15]. This is an issue that requires considerable further investigation in the months ahead.

[15] It would have been helpful if the Commission had included a Sankey diagram for the bioenergy sector, or even the bioeconomy as a whole, and it could be invited to do so at a future date.

Figure 84: Break down of bioenergy feedstock in 2050



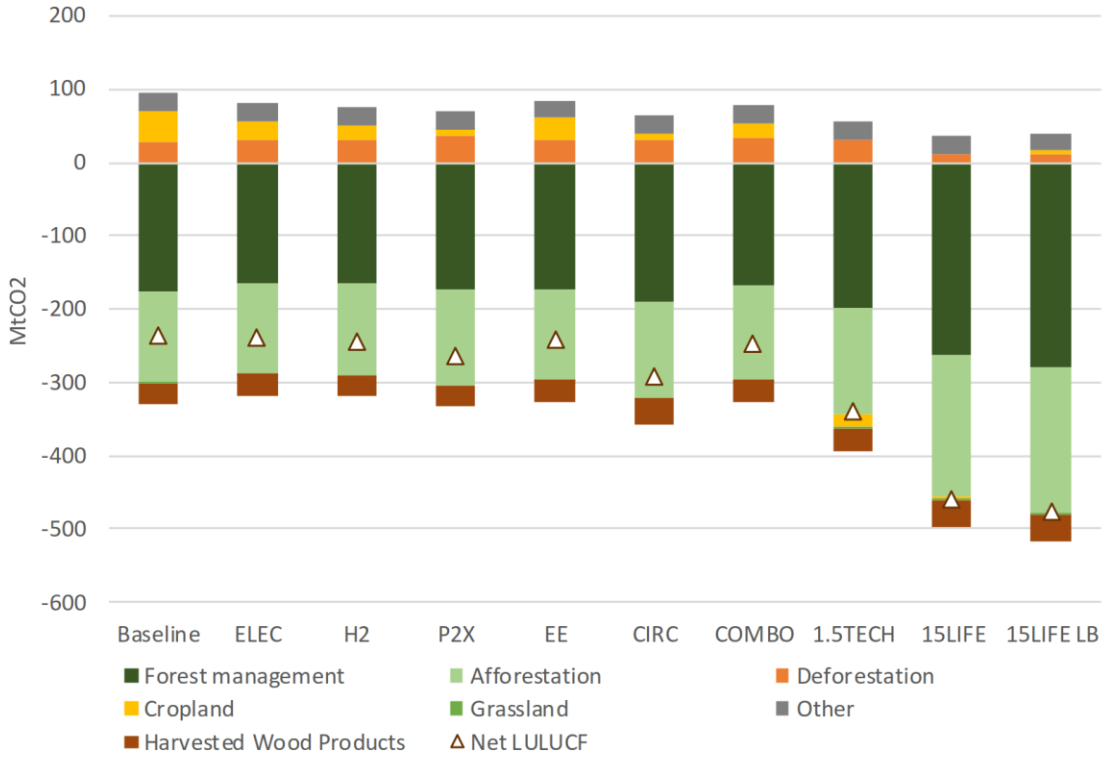
Source: PRIMES, GLOBIOM.

4.8 Towards negative emissions

Decarbonising the EU economy will principally be achieved by cutting emissions to zero (or close to zero) in all sectors. **Carbon dioxide removal** (CDR) from the atmosphere, sometimes referred to as negative emissions, is no substitute, and cannot be an excuse to avoid doing the former. However as the Commission explains, there are some emissions that in the foreseeable future it will be extremely difficult if not impossible to eliminate completely, for example in the agriculture sector. Given the failure by developed countries to cut emissions dramatically over the last thirty years, it is also now likely that some measure of CDR will be essential to keeping global temperature rise below 1.5C, above which the impacts risk becoming catastrophic.

The most promising option for CDR is to **increase the natural sink**, which the Commission notes can be achieved "through ecosystems restoration, afforestation, reforestation, improved forest management and enhancing soil carbon sequestration" (figure 87 below illustrates the extent to which the LULUCF sink could be enhanced under the different scenarios). Many of those options would also provide significant additional benefits, whether to agricultural productivity, water and flood management, biodiversity and human wellbeing, and their sustainable deployment should urgently be prioritised. Particularly important, as the Commission notes in the previous section on land use, is the enhancement of the forest carbon sink, which as EU forests recover from centuries of over-harvesting already sequesters a small but significant fraction of overall EU emissions.

Figure 87: LULUCF emissions across the scenarios



Source: GLOBIOM.

Where the Commission's analysis is flawed is in relation to dedicated **energy crops**, which as explained above are counterproductive in climate terms even taking account of the displacement of fossil fuel. So when the Commission says that "the substantial use of woody energy crops instead of stem forest feedstock wood limits the negative impact on the forest sink and therefore helps to maintain the overall LULUCF sink in all scenarios" it is simply trading one potential sink (the land it proposes be used for energy crops) for an existing one (land that is already forested). Such a policy may well 'help to reverse the trend in farmland abandonment and offer to farmers new economic perspectives', but it is not a policy that should be pursued on climate grounds. On the contrary, farmers should be encouraged actively to return marginal or abandoned land to natural, carbon rich ecosystems such as forest, to maximise mitigation. EU policies that prevent such an outcome (for example, minimum requirements under the Common Agricultural Policy that land be kept clear of vegetation so it remains suitable for agriculture) should be reviewed, and only accepted when the maintenance of agricultural activity has other explicit benefits (e.g., biodiversity conservation).

Another important consideration is that any incentives relating to afforestation, reforestation or sustainable forest management must be environmentally sound. Long term carbon sequestration in forests is most likely to be successful, particularly given increasing climate-related stress, if it is in the form of resilient, diverse, natural forests in ecologically suitable areas. Such action will also bring the greatest co-benefits (see above) as will the restoration of other carbon rich ecosystems such as wetlands.

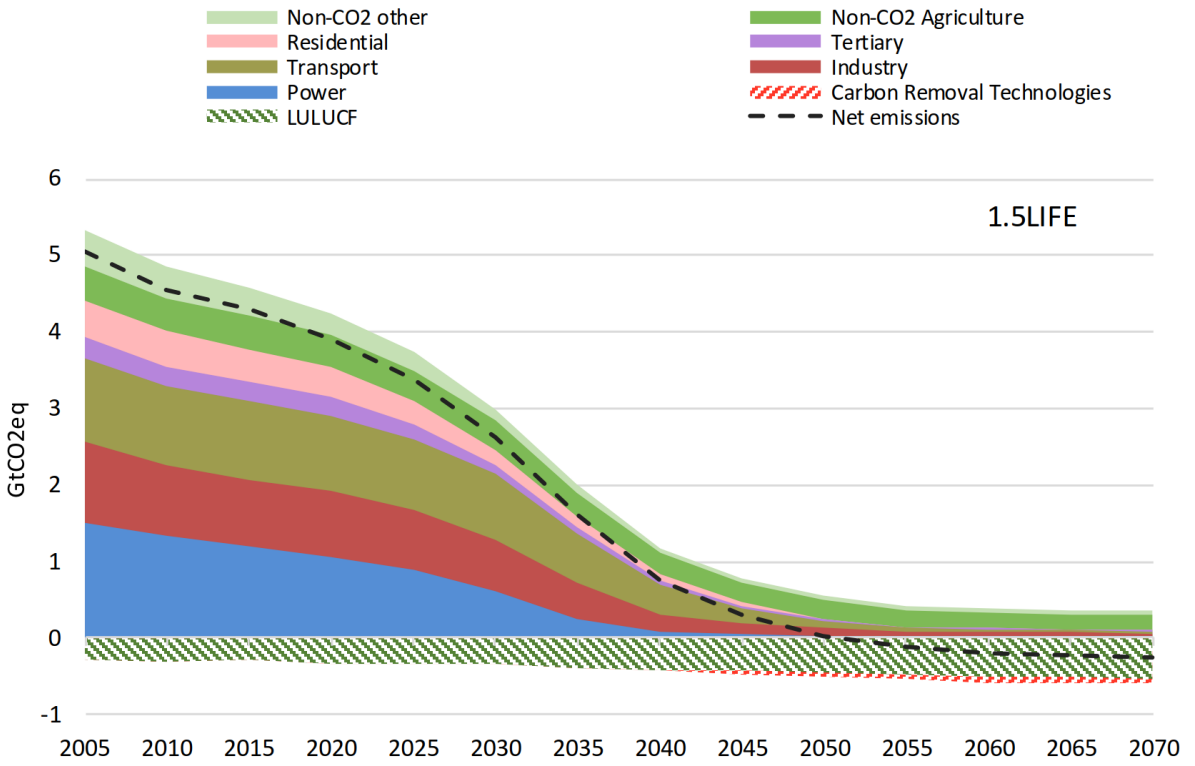
As regards the other more 'technological' approaches to CDR examined in this section, the Commission notes that these are mostly "only at an exploratory stage and that none of them are sufficiently mature for large deployment". The potential difficulties with those considered in the scenarios are also well known, for example that BECCS would require vast areas of land and may in many cases not deliver better climate outcomes than reforestation, and that DACCS, although not necessarily demanding of productive land, would likely require enormous amounts of energy. These drawbacks reinforce the need for very rapid reductions in emissions; however difficult and costly such reductions may appear, they will in all likelihood be much easier and cheaper than sucking CO_2 back out of the atmosphere after it has been emitted.

4.9 Economy wide greenhouse gas emission pathways

This short section summarises the economy-wide GHG impacts of the scenarios discussed in the earlier sectoral chapters, and illustrates the speed and ambition of emissions reduction (or CDR) in different areas of the economy. As the graph from figure 90 below makes clear, the power sector is one of the fastest to decarbonise in the 1.5LIFE scenario (this is true in all scenarios) with residential and tertiary buildings and non-CO_2 emissions

also falling relatively quickly - reflecting the availability in such sectors of existing, commercialised solutions. Industry and transport decarbonise more slowly, along with agriculture, which by 2050 makes up the majority of remaining emissions.

What is particularly noticeable is the trajectory that results from the Commission's decision not to change the level of ambition in 2030 beyond what can be expected under current targets and policies. As can be seen from the graph below, the rate of emissions reduction is relatively modest during the 2020s, but accelerates dramatically in the 2030s. A straight line over this time period would itself already imply an increasing percentage annual reduction, but a convex curve, as shown here, implies significantly delayed action, and improbable annual rates of reduction at a later date. More realistic - and cost effective - would be a concave curve, for example one based on a constant percentage reduction per year, meaning higher absolute reductions in the nearer term when there are still (relatively) low-hanging fruit to pick, and smaller absolute reductions later, as every additional tonne of mitigation effort becomes harder. Such a trajectory - and therefore an EU 2030 GHG target of well above 40% - would also result in significantly lower cumulative emissions, and be closer in shape to the global trajectories consistent with 1.5C presented by the IPCC in its recent report.



Source: PRIMES, GAINS, GLOBIOM.

4.10 Economic aspects of energy transformation and decarbonisation pathways

Perhaps the most important point to note in relation to this section of the analysis is that, as the Commission says in the strategy itself, its cost estimates "do not include **the benefits of avoided climate change and related adaptation costs**". This arguably makes the entire section irrelevant, but even without such benefits, and despite the additional investment required in all sectors of the economy, the Commission says that the "overall economic impacts of the deep transformation required are positive".

According to the baseline macroeconomic **growth projections** underpinning the modelling for the strategy, the Commission expects real EU GDP in 2050 to be about 2.5 times what it was in 1990. As regards the impact on this of the transition to a zero net emissions economy the Commission modelling suggests that this will be 'moderate' (the Commission describes various different analytical approaches, assuming different levels of global as opposed to EU action, and concludes that achieving zero net emissions would have only limited effects on broad economic aggregates such as GDP, consumption or employment - whether positive or negative - and that "leading the way on decarbonisation actually entails some gains for the EU in terms of GDP rather than costs"). The Commission also argues that its modelling suggests that the decoupling of GDP growth and GHG emissions,

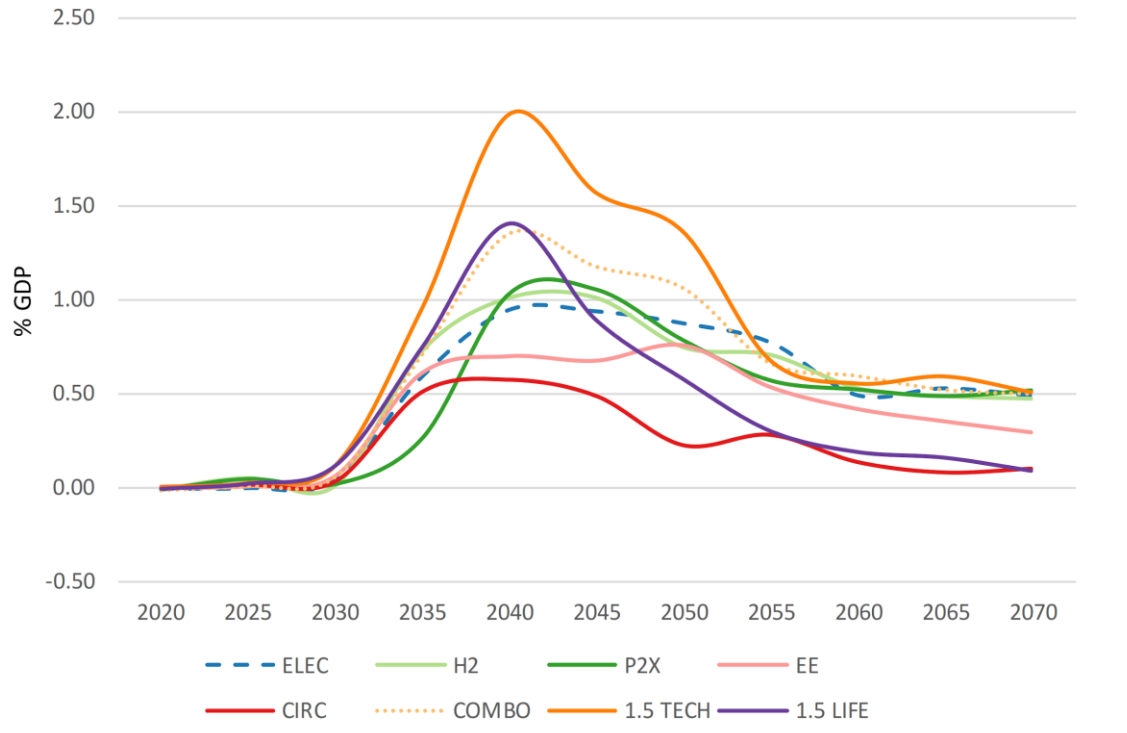
which has already started, can be completed, with output per unit of gross inland energy consumption increasing by a factor of two to three, depending on scenario.

As regards **investment**, the Commission notes that previous impact assessments suggest that an additional EUR 177 billion in annual investment would be needed to reach the 2030 climate and energy targets, although it now expects this to be 15% lower, despite the higher 2030 targets for renewables and energy efficiency, due to the fall in the cost of renewable energy technologies.

As regards the post-2030 period, the Commission.estimates that average annual investment in the energy system and related infrastructure over the 2031-2050 period (excluding transport, in which "most of the investment represents the replacement of the vehicles as a whole") would be 1.9% of GDP under the baseline, 2.4% in the 80% emissions reduction scenarios and 2.8% for the zero net emissions scenarios. There are significant differences between scenarios, however, with the CIRC, EE and 1.5LIFE scenarios - because of the emphasis on efficiency and circularity, involving significantly less investment than scenarios that achieve similar GHG outcomes. As the Commission puts it: "The modelling…shows the potential of the circular economy and lifestyle changes to reduce additional investments overall. These pathways indeed require a total level of annual investment around 5% and 8% lower, respectively, than that of the other pathways with a similar level of ambition."

It is also important to note that the level of investment in GDP terms remains at around current levels in all scenarios up to 2030 - a function of the fact that the Commission modelling assumes no change to the 2030 targets and therefore delays any significant action on climate change until after that date - creating a dramatic 'hump' in investment between 2030 and 2050 (see Figure 95, reproduced below).

Figure 95: additional investments (including transport) compared to Baseline in % of GDP



Source: PRIMES.

As the Commission rightly notes, there are clear trade-offs when it comes to the level of investment required, and hence the costs of the transition. Scenarios that involve high levels of energy efficiency and circularity (including through lifestyle changes) require significantly lower levels of investment - particularly on the supply side - compared to those that involve greater use of (expensive) technological alternatives such as hydrogen and other synthetic fuels, or options such as BECCS. In all decarbonisation scenarios investment in power generation and the electricity grid increases significantly, which is as expected given the need to electrify heat and transport.

In terms of total EU **energy system costs**, the Commission modelling suggests that these will rise in absolute terms under all scenarios, including the baseline, but as a percentage of GDP they fall dramatically from around 2025 onwards under all scenarios - and fall most under the 1.5LIFE scenario (see figure 98 below). The exception

is the 1.5TECH scenario, under which costs as a percentage of GDP remain at approximately current levels until around 2050.

As regards the impacts of the various scenarios on **household consumers**, the Commission notes that energy-related expenses increase in absolute terms under all scenarios, including the baseline. But in real terms (i.e. taking into account inflation, rising GDP and rising household incomes) energy-related expenses in 2030 are expected to be about the same as in 2015. Beyond 2030 the changes depend on the scenario, with expenses for households being highest under the 1.5TECH, P2X and H2 scenarios, but being lower than the baseline scenario for the 1.5LIFE, EE and CIRC scenarios. As the Commission rightly notes, energy-related expenses as a fraction of income vary widely between Member States, reinforcing the need for increased energy efficiency measures over the next decade to support vulnerable consumers exposed to energy poverty.

As regards the cost of **fossil fuel imports**, the Commission projects that this could be €421bn per year on average from 2021-2030, and "would continue to grow without strong decarbonisation". However under the decarbonisation scenarios, fossil fuel imports fall dramatically after 2030, leading to cumulative savings for the EU over the 2031-2050 period of €1.4-3.0 trillion. As part of this, the Commission projects that imports of natural gas 'in a decarbonisation context' can be expected to fall by 60-92% by mid-century. As for GHG emissions, cost effectiveness and health benefits, this raises the question of why the EU should seek to make such limited progress on decarbonisation during the 2020s, and delay serious action until the post-2030 period.

On **employment**, the Commission's modelling suggests generally positive outcomes, from around 0.5 to 2.1 million additional jobs in 2050 under the decarbonisation scenarios compared to the baseline (with the higher figures being for those scenarios that reach zero net emissions). This is in line with previous research the Commission cites that concluded that the shift from fossil fuels to renewable energy would increase employment in the EU and that the expansion of employment in the green energy sector would outweigh 'the compression in the declining fossil fuel sectors' - in part because the EU is currently a net importer of fossil fuels. Positive employment effects have also been found for energy efficiency measures.

While the shift to a zero net emissions economy will in the Commission's view have impacts on the mining and extraction industries, these are said to account for small shares of total employment, and in most cases occur even under the baseline scenario. However as with the industry and manufacturing sectors, which are also projected to face changes (albeit more limited) in employment patterns, the need to ensure a just transition will be paramount. In all but the extraction and mining sector, under the least favourable scenario, the Commission projects that any decline in jobs can be absorbed by retirement.

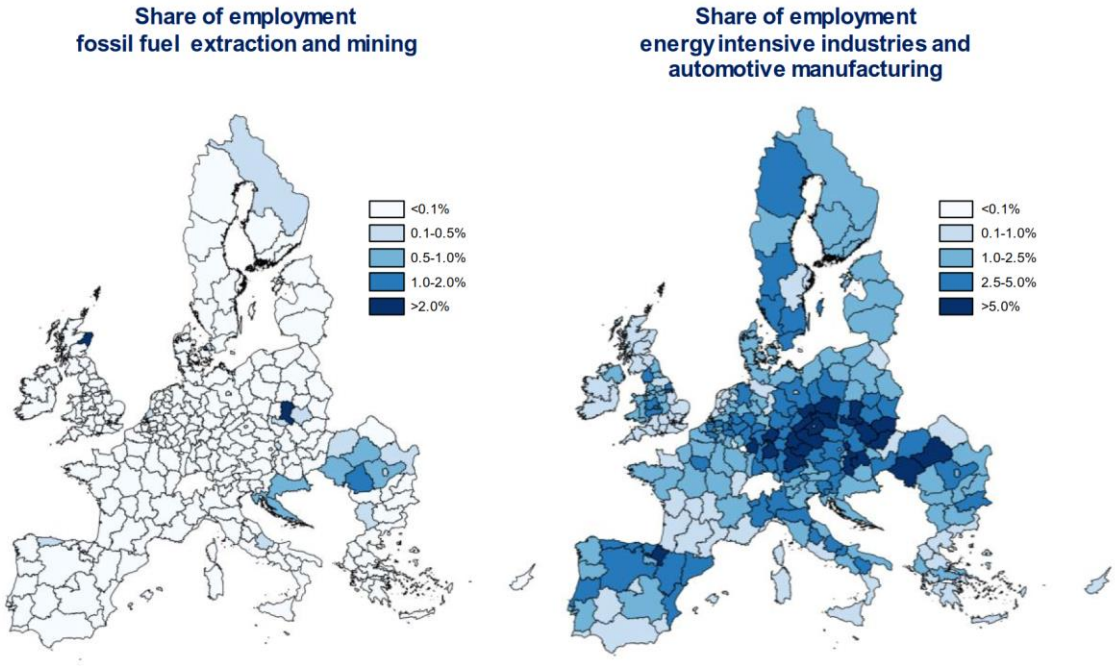
5. Cross-cutting factors

5.1 Regional employment aspects, education and skills

The section is very positive on the overall contribution of the green economy to overall employment. It highlights early on that most estimates (and historical trends) suggest the EU job market will benefit from low-carbon transition climate policies (by up to 2 million jobs by 2030 according to the International Labour Organisation). And the Commission notes that green jobs are resilient in recessions and are "often quality jobs contributing often also to local (non-outsourceable) employment in rural or disadvantaged areas and thus to social reinsertion and territorial cohesion". In particular, regions that are involved in the production of renewable energy are likely to benefit significantly.

However as the Commission makes clear, while "overall gains more than offset losses between and within sectors", the transition will entail challenges for certain regions whose economies depend on sectors that are expected to decline or that will have to transform. At EU-level, three regions are highlighted as facing particular challenges, as they have have employment shares of more than 1% in sectors expected to decline (extraction and mining): NE Scotland, Silesia and Sud Vest Oltenia. Twenty-four other (often poor) regions with a much greater geographical spread have industries that will need to undergo significant low carbon transformation - for example regions that have employment shares greater than 1% in energy intensive industries and automotive manufacturing.

Figure 107: Regional exposure to sectors that will decline (left) and transform (right)



Source: Eurostat SBS[490].

In terms of how to address the challenges, the Commission's SWD notes that realising the potential for transformation, which is likely to benefit most regions, depends on policies. Moreover, the transition will create challenges in terms of skills shortages, as skills cannot be transferred perfectly from one sector to another, particularly in the case of workers with lower levels of qualification. The need for more highly skilled workers will increase up to 2030 and on to 2050. Therefore for a just transition there will be a need to actively align education and training policies with emerging skills needs, and to ensure everyone has the basic 21st century skills/key competences needed for the transition.

5.2 Role of finance

This chapter starts with the statement that "the financial sector will play a critical role in enabling the decarbonisation transition and in funding the appropriate types of investments at the scale required. Fulfilling this role will require a transformation of the sector itself." The Commission also argues, surely correctly, that "private finance will have to account for the bulk of investment needs".

However while noting that "the long-term liabilities of pension funds make them ideal providers of sustainable finance, and the business model of the insurance sector is particularly well-suited to supporting sustainability", the Commission points out that "investment in low-carbon technologies still accounts for a very small share of institutional investors' assets" and that some recent analysis "found that the share of green investment in the portfolios of pension funds and insurance companies is around 1-2%".

The Commission is therefore right to say that change is needed to "systematically re-orient private capital towards more sustainable investment", and to argue that markets and credit risk agencies need to price climate risk properly and that companies and financial institutions need to "think long term and be transparent about their operations". In this context the Commission goes on to list a number of helpful initiatives, for example on a taxonomy for sustainable investment, on benchmarks and on disclosure requirements.

What the Commission fails to mention is perhaps the best means of addressing regulatory uncertainty, namely the existence of credible, legally binding GHG targets and robust policies to deliver them. Urging investors to 'do the right thing' is fine, as far as it goes, but is no substitute for giving the finance sector a clear sense of direction. If politicians want to minimise the costs of the transition to a zero net emissions economy then setting long term, economy-wide, enforceable objectives for emissions reduction is indispensable.

5.3 Industrial competitiveness

The strategy is very positive about the expected economic impacts of transitioning to a carbon neutral economy, emphasising that the new green jobs created will be local, high quality employment. The underpinning analysis

indicates investment needs of around 25 billion per year for the industry sector to enable the transition. It makes clear that EU industry has the opportunity to become the leader in the transition to a carbon neutral economy, changing to more sustainable and resource-efficient business models, products and services that could then become the paradigm for other countries and regions. This would provide a competitive advantage, creating significant cost savings and spurring innovation. Europe would be able to export not just sustainable products, but also sustainable technology and business models to exploit the huge potential of the global market for low-emission solutions.

Managing a just transition through reskilling/upskilling will be key, including for energy intensive industries and regions such as those in Central and Eastern Europe that are dependent on them. The Communication reaffirms the EU's commitment to lead in global climate action, but also that this strategy cannot be pursued in isolation. The Commission argues that open markets, free trade and global climate action will be crucial to allow for the transition, and European environmental product standards have impacts far beyond Europe.

Securing competitiveness, the Commission outlines, will require an integrated and systemic approach covering:

- The sustainable supply of raw materials
- Optimised material flows in cross-sectoral value chains supporting circular economy and industrial symbiosis.
- Energy and resource efficiency
- Breakthrough decarbonisation technologies, innovative materials, digital and space technologies, social innovation large-scale demonstration projects.
- Demand-side measures to stimulate the creation and the fast development of markets for low and zero-carbon products/solutions

The language in the document indicates the need for a policy framework that can facilitate the needed investment, support innovation and incentivise all the necessary changes, without jeopardising the global competitiveness of European industries. The strategy highlights that infrastructure that is invested in over the next 10 years will most likely still be in place in 2050, meaning it is critical to ensure that proper incentives are given - starting today - for low carbon investment. This is a welcome recognition by the European Commission, but again is at odds with its decision not to propose any change to the EU's existing 2030 GHG target, and therefore to delay until the 2030s the level of action required.

5.4 Role of research and innovation

The Commission's analysis recognises that research and innovation will play a crucial role in the transformation to a zero carbon economy, both by maximising the opportunities for society and by minimising the risk of lock in and stranded technologies. The Commission also notes, importantly, that long investment cycles require a long term perspective, meaning a focus on well beyond 2050. The SWD identifies a number of different research areas (see figure 109 below) that are discussed briefly in the document. Whilst most of this section is uncontroversial, the following points are worthy of note:

- Electrification means that "batteries will become one of the key technological components of a low-carbon economy", but this is an area in which the EU is "lagging behind".
- Efficiency and a more circular economy are "first obvious win win measures" when it comes to the environmental footprint of energy and material intensive industries.
- There are important trade-offs between bio-based alternatives and the need to increase carbon sequestration in land or soils, and there are therefore system-wide research issues on how to use available land in the best way (in this context a recent paper in Nature explores precisely this question, and proposes a 'carbon benefits index' as a way of assessing the best use of land in a climate context - further information can be found via the relevant WRI site[16]).
- 'Social innovation', for example in relation to lifestyle choices and the sharing economy, will be essential.
- "…the EU is progressively falling behind, spending comparatively less on research than other regions". "In 2015, the EU spent 0.02% of GDP on energy-related research…[and]…in sheer number of patents, Europe is being outnumbered by Japan, China and, more recently, by South Korea."

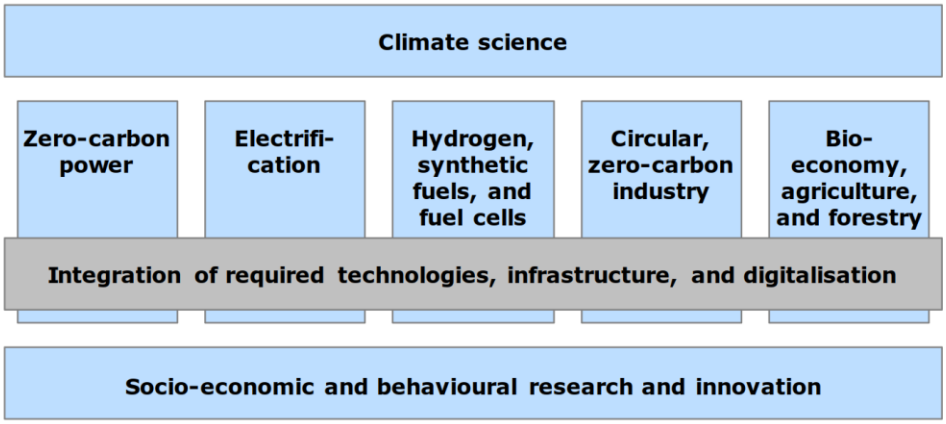
The Commission cites a number of tools and instruments to deliver on low carbon technological solutions, including the following very welcome suggestions:

- "Levelling the playing field - removing fossil fuel subsidies and internalising the climate change externalities of GHG-emitting technologies is necessary in order to allow zero-carbon technologies to compete"

[16] https://www.wri.org/carbon-benefits-index

- "Conflicting policy objectives" (unspecified, but one would hope a reference to the EU's seriously flawed bioenergy policies);
- New instruments…to introduce economic incentives for enhanced life-cycle performance, durability, upgradeability and ease of repair and recyclability"
- "Fiscal policies [that] focus more on taxing capital and consumption than labour."
- "More reliance on polluter pays principles. "
- "Stronger focus on Circular Materials rather than waste e.g. 'Circular Materials Framework Directive' consolidating and simplifying waste legislation"
- "[the adaptation of] competition policies…in order to allow subsidised large-scale demonstration of systemic solutions at reasonable scale."

Figure 109: Relevant research and innovation areas



5.5 Lifestyle and consumer choices

As the Commission notes in this section: "demand-side solutions related to consumer choices are powerful tools to reduce the carbon footprint of our economy with a clear potential for co-benefits to citizens themselves and society as a whole". It goes on to say that "to achieve the transformation, it is important to move consumer needs and rights into the centre of policy discussions". Given these statements, and notwithstanding the references to diets and transport choices elsewhere in the document, it is regrettable that the Commission devotes only one of four hundred pages to this subject in its SWD and makes no mention of it at all in strategy communication itself. Such issues clearly appear sensitive to politicians, but their importance to the transition to a zero net emissions society cannot be ignored. Not only will they - as the Commission puts it "help to diversify decarbonisation pathways" and (to the extent that they are not achieved) imply "larger use of not yet mature technologies such as biomass and CCS…or direct air capture and CCS (which has not yet been demonstrated at a large scale…)" but they are likely to be essential to any global achievement of the Paris Agreement goals.

While the Commission says that "soft" measures such as information campaigns and labelling programs can play a significant role across a wider set of products and services" and that hard measures such as "standards and norms…allow removing inefficient technologies from the market that often would be to the detriment of consumer welfare in the longer term", it fails to go any further, saying only that "policy making will have to look at how to engage citizens with appropriate economic and fiscal instruments". This is a major gap in the Commission's draft EU strategy and the underpinning analysis.

5.6 The international dimension, implications for the EU Long Term Strategy

This is, deservedly, one of the longer sections of the SWD and starts by making the important point that the destabilising impacts of climate change "…including disruptions in food security, reduced access to resources, water and energy, the spread of epidemic diseases and social and economic instability – make it the ultimate threat multiplier". It goes on to discuss the many international aspects of the low carbon transition, from the changes to geopolitical influence of fossil fuels supplying countries and the cybersecurity risks related to an increasingly electrified and digital energy system, to the threats to the supply of raw materials essential to low carbon technologies.

What is most striking, however, is the extent to which this section discusses past action and existing international processes. While the Commission sets out the issues clearly and laments the fact that we "have been overtaken in recent years by other large economies" when it comes to things like renewable energy, there is very little mention

of what action the EU or others might take in response, beyond general calls for future policy initiatives and further international cooperation. On the one issue that would arguably involve concrete changes, the imposition of border tariff adjustment, the Commission goes to some trouble to set out the many legal and practical difficulties, as if seeking to kill off an issue that it expects to be the subject of later discussion.

A similar approach is taken to the question of 'embedded' or 'consumption' emissions, meaning the argument that instead of relying on production based accounting (PBA) the EU should be taking into account the emissions for which it is responsible outside its territory, through the goods it imports. The Commission argues, on the basis of new analysis it has commissioned, that the difference between PBA and consumption based accounting (CBA) is slight, and that if account were taken of the carbon efficiency of EU production then the picture would be positive, on the grounds that "the EU [has] already contributed significantly to the reduction of emissions in other countries because of…the improved carbon efficiency of its exports". The Commission admits that its analysis paints a more positive picture than other studies, and in WWF's view it masks the very negative impact of EU consumption of global commodities that drive emissions (and land use change) elsewhere - including as a result of the EU's seriously flawed bioenergy policies.

As regards the integration or mainstreaming of environment and climate change into development cooperation programmes, recent updated guidelines for EU delegations are fairly detailed, including sectoral guidance and climate screening. How much these are used by the delegations is an open question and probably depends on the interest and awareness of the programming officer.

The EU does provide significant climate finance through its international development cooperation instruments and should continue to do so, particularly responding to country priorities in terms of NDCs, NAPAs, etc. However, as is clear from this section, the EU is increasingly looking to the private sector to deliver, through a number of new instruments which reduce risk and provide guarantees for private sector investment. ODA is used as leverage in these cases and the private sector concerned often privileges European companies. The contribution of the private sector is of course critical, in particular for mitigation, but these new instruments make big assumptions about the potential amount leveraged (which have not been tested) and of course there are opportunity costs in terms of the amount of public ODA which is ring-fenced for these purposes and cannot be used in the meanwhile for other development objectives. Concerns have been raised by many CSOs, including WWF, about the lack of transparency and lack of assurances of strong environmental and social safeguards. The potential for using these instruments for adaptation is also not proven since there are less likely to be profitable returns to attract necessary private sector investment.

5.7 Interactions with other Sustainable Development Goals

This short (2-page) section highlights both the opportunities to enhance sustainable development through action on climate change (due to co-benefits such as improved air quality) and the potentially severe risks that would be posed to achievement of many SDGs (including those relating to biodiversity) if climate change could not be stopped. It does not go into any great detail and instead summarises the SDG-related content of the recent IPCC special report on 1.5°C (which only focuses on the interactions between mitigation and the SDGs).

It suggests that the EU can show leadership by identifying how to manage potential trade-offs but does not also mention that EU can show leadership by maximising synergies. Although it points out that the EU and its MS have in turn committed to implementing the 2030 Sustainable Development Agenda in full, it fails to state that currently – several years on from the adoption of the SDGs – the EU has no implementation strategy and is only promising a "Reflection Paper".

This section of the SWD glosses over the potential of agriculture's contribution to climate change - ignoring the benefits that could be gained by CAP reform - and also omits to mention the contribution EU makes to forest degradation and deforestation in other countries through its own consumption of, eg, oil palm and soy (see above) and the benefits of healthy forests for both mitigation and adaptation. These impacts are important from the point of view of EU claims on sustainable consumption and production.

5.8 Air pollution benefits from climate action

In 2018, WWF published the Dark Cloud report, together with HEAL, Sandbag and CAN. This highlighted the huge health care costs and the potential prolongation of life (avoiding 22,900 premature deaths per year) that the phase out of all EU coal plants could achieve. The SWD makes clear that climate action is increasingly proven to provide co-benefits for air quality of 'significant scale', but only very briefly.

The CIRC and 1.5LIFE scenarios offer the greatest reductions in air pollution, resulting in up to a maximum estimate of €418 billion euros in health damage reduction. The 80% reduction scenarios offer smaller benefits. This provides strong arguments in favour of the 1.5LIFE scenario, and further efforts to improve the circular economy and reduce overall emissions.

5.9 Climate change and its impact, how to increase resilience and adaptation

As the Commission rightly acknowledges, "climate change is already occurring and its impacts are already being felt across Europe" and notes that "last year, the global economic costs of weather-related disasters hit a record of € 283 billion". This section of the SWD makes clear some of the stark consequences for the EU and elsewhere in the world of rising temperatures, whether in terms of agriculture or the loss of whole ecosystems, and the many synergies between adaptation measures and those related to climate mitigation or achievement of other SDGs

The EU is one of the few donors that has managed to achieve a good balance between support for mitigation and adaptation, with many donors focusing on mitigation alone. EU commitments in this regard should be acknowledged and continued: many LDCs need this support from public funding (ODA) for adaptation and resilience in the poorest regions and will not attract private sector investment to this end, investment that entails loans and with them the expectation of returns on investment.

Finally, while the risks to the EU and other countries as a result of climate change are hard to overstate, the Commission's reference - on the basis of one study - to the relationship between climate change and asylum applications in the EU is misguided. People can only claim asylum due to fear of persecution due to race, ethnicity, political or religious beliefs or sexual orientation – not climate change. No doubt there will be many people displaced due to natural disasters or who will migrate due to climate change having made their livelihoods impossible, but they will not be asylum seekers and will not necessarily seek to come to EU. There are many important reasons for the EU to support adaptation in the global context, not least that climate change will reverse progress on poverty reduction, equality and sustainable development, in which the EU has been investing for many years. But this is yet another example of the EU making migration fit the current political arguments that migration is a threat.

6. Role of different actors in the achievement of low carbon and energy transformation pathways

6.1 Role of Member States

This section is extremely short and is essentially limited to making the (obvious) point that national Governments are key players in the energy transition, as they will need to make the crucial decisions to adjust the energy system and the other parts of their economies to a zero net emission society. As the Commission makes clear in this section, Member States are also required to prepare national energy and climate plans and national long term strategies, which need to be consistent with each other and with the EU's own EU Long Term Strategy.

6.2 Role of regional and local authorities

This section makes clear the pivotal role that cities and regions play in achievement of EU energy and climate objectives, particularly as 'delivery agents' of implementation, and that taking into account regional and/or local climate and/or adaptation plans will only strengthen those agreed at national level.

It is welcome that more of an effort has been made to help cities and regions fund the development and delivery of energy and climate legislation, including via a new Urban Investment Support Service (URBIS) fund, as well as there being an increase of 1% in the European Regional Development Fund. While this increase (to 6%) isn't what was hoped for by beneficiary constituencies, the creation of an additional fund does show that due consideration is being paid to them, although it's not clear how much money this new fund will have to disburse.

More generally, the observations in this section reflect to a great extent the benefits (and address the concerns) highlighted by stakeholders involved in the WWF MaxiMiseR project on national long term strategies (see below), particularly the identified associated benefits of including cities and regions in the development and implementation of policies, e.g. continuous political support, ownership, feedback loops, shared responsibility and better implementation of the required action.

This section also highlights the Covenant of Mayors for Climate and Energy, hinting at an openness to bottom-up initiatives. However, the means of institutionalising these inputs is unclear from the SWD. An important point made in the SWD in relation to defining the important elements of successful cooperation between EU/national government and the local level is that the SWD stresses that where there are national binding requirements, local climate plans are more likely to include both adaptation and mitigation plans.

6.3 Role of business and civil society

This one-page section includes a brief overview of initiatives within the business and civil society sectors, the views expressed in the public consultation and the importance of those sectors' full involvement in a successful transition to a zero net emission society. There is a reference in this section to the WWF Life-funded MaxiMiseR project on national long term strategies, alongside the 2050 pathways initiative supported by the European Climate Foundation.

WWF®

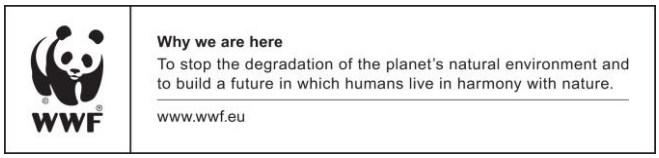
The EU long term climate strategy

WWW.WWF.EU

For further information:

Imke Lübbeke
WWF European
Policy Office
Email:
iluebbeke@wwf.eu
Phone: +3227438818

Alex Mason
WWF European
Policy Office
Email: amason@wwf.eu
Mobile +32494762763



© 1986 Panda Symbol WWF - World Wide Fund For Nature (Formerly World Wildlife Fund)
® "WWF" is a WWF Registered Trademark.

EU Transparency Register Nr: 1414929419-24
Printed on recycled paper.