ANALYSING THE IMPACT ASSESSMENT ON RAISING THE EU 2030 CLIMATE TARGET

HOW DOES THE EU COMMISSION'S APPROACH COMPARE WITH OTHER EXISTING STUDIES?

BRIEFING

30 SEPTEMBER 2020

This briefing has been commissioned by the European Climate Foundation (ECF) with a view to providing a basis for discussion and engagement between stakeholders and policy-makers. The ECF is not to be held responsible for any use which may be made of the information contained therein.

The analytical team

CLIMACT: Jerome Meessen, Julien Pestiaux, Quentin Schobbens, Quentin Jossen, Benoit Martin, Charles Vander Linden, Pieter-Willem Lemmens

ECOLOGIC INSTITUTE: Katharina Umpfenbach, Eike Karola Velten, Ana Frelih-Larsen, Benjamin Görlach

CONTENTS

Executive summary **4**

Context and objective of this report **7**

A whole system view on policy levers and cross sectoral links **9**

Options for transforming the EU climate policy architecture 9

Recognising the interdependence across sectors 13

Analysing sectoral ambition in the Impact Assessment **16**

Overview of emissions reduction by sector 16

Power 16

Transport 18

Buildings 21

Industry 24

Agriculture, land use and bioenergy 25

References **30**

ANNEX: Detailed sectoral implications of the IA scenarios compared to the CTI scenarios **32**

EXECUTIVE SUMMARY

The Impact Assessment (IA) just released by the EU Commission on raising the EU's 2030 climate target is a critical piece of work to guide the transition to a net zero emissions economy. This briefing strives to unpack some of the key policy options and analytical results by comparing them to other recent studies, in particular the CTI 2030 scenarios (CLIMACT 2020). We have looked at the IA both from a **high-level policy and cross-sectoral point of view**, as well as in terms of **sectoral developments and policy actions required at that level.** Given the short time frame available for this analysis, the briefing is necessarily limited in scope and depth. Its main aim is to highlight key points where the Commission diverges from other studies, proposing avenues for strengthening future analysis. We also limited this analysis to reaching at least -55% for a fair comparison. The CLIMACT prior analysis however shows that reaching -65% (excluding LULUCF) is technically feasible.

The IA assesses **options to introduce EU-wide carbon pricing for buildings and road transport** which are currently covered by the Effort Sharing Regulation (ESR). In opting for exploring the extension of the EU Emissions Trading Scheme (ETS) to these new sectors and leaving open what this would mean for the ESR, the Commission proposes to substantially alter the EU's existing climate policy architecture. At the same time, the Commission acknowledges that carbon pricing alone will not be sufficient to reach the 2030 target**,** arguing for a mixed approach which combines carbon pricing with strengthened regulation. This is in line with scientific evidence on the strengths of policy mixes compared to a pure pricing approach. It is also warranted from a risk management perspective: setting up a functioning carbon pricing mechanism will be a challenging, time-consuming and politically sensitive process. It will require detailed analysis on effective mechanisms to address distributional effects within and between Member States. **The IA has not looked into the distributional effects** since that can only be done based on a set of design options with details on revenue recycling. **Such analysis will have to be a crucial element of the instrument-specific IA**. As long as a carbon pricing scheme for road transport and buildings emissions is not in place and has not yet proven to effectively cap emission volumes in a socially just fashion, it would be extremely risky to toss out the functioning system of compliance control that is the ESR. Even in the longer run, there is an argument for **keeping the ESR**. It would serve to ensure that national governments implement climate policies that address the transformation as a systemic challenge, supporting private actors in their mitigation efforts, e.g. by rolling out the supporting infrastructure and the regulatory framework such as stringent CO_2 standards for new cars.

As for the concrete policy levers included in the scenarios, our findings show that some key additional avenues exist and could be explored to further support emissions reduction. **The scenarios included in the IA tend to be technology-focused without addressing much the impact of potential societal changes, as well as missing a true vision for a circular economy by 2030.** These are not just possible additional options, they are necessary to make the climate transition realistic, turning it into a true sustainable vision for Europe. A typical example is to ensure all products are built to last much longer with higher added-value over their lifetimes, which in many cases will require the proper incentives to change business models, turning products into services.

A purely technical approach will lead to new sustainability issues with larger investments requirements across all sectors, increases in demand for electricity and key raw materials. This will result either in significant infrastructure build-outs or increased dependence on imports from countries where Europe will have limited say on the climate ambition. All of these risks can be better managed if the Commission’s approach is supplemented with policies incentivising improvements in our societal organization and a more circular economy. Some of these additional policies however require the initiative of Member States which further confirms the relevance of the ESR.

On the other hand, the technical ambition at the sectoral level in the IA must be praised, the IA scenarios explore a real change in the scale of ambition. Focusing on the three IA scenarios reaching -55% (including LULUCF but excluding international bunkers), the following insights emerge:

- In the **power sector**, the low-carbon vision is clearly spelled out, with significant increases in renewable-based electricity production. The coal phase-out is the cornerstone for a sustainable power sector, but the question remains as to how quickly gas must also be phased-out. The IA scenarios reach ~-70% greenhouse gas (GHG) emissions in 2030 compared to -90% in the EU CTI scenarios (compared to 2015). This lower ambition in phasing out fossil-fuel use in electricity generation leads to the need for higher ambition in the other sectors.
- In the **transport sector**, the shift to clean vehicles is starting in earnest, with 20-25% of the car stock required to be low- or zero-emission in 2030. For the fuel switch, the policy mix will have to focus on regulatory measures besides a carbon price to target the vehicle purchase decision and to address that the willingness to pay is much higher in transport than in other sectors. The technology shift is compatible with demand-side measures which are not much addressed in the IA, e.g. to curb the growth of the transport demand and incentivize modal shift to non-motorised mobility. Overall transport volumes are expected to further increase in the IA scenarios, which means that the focus on fuel switch may result in a raw material demand which is too high, especially related to batteries .
- With respect to **buildings,** the fuel shift is of a new order of magnitude, with fossil fuels consumptions reduced by 58% in 2030 compared to 2015. In absolute terms, this a decrease of 815 TWh, mainly driven by a phase-out of coal and oil use, supported by energy efficiency investments and a shift to electricity and renewables. According to the IA, a mix of regulatory measures addressing the multiple challenges in building renovation and the introduction of a carbon price including consideration of risks such as energy poverty are expected to make this change happen.
- In **industry** the ambition on the technological shift is real, although major levers such as fuel switches (e.g. to electricity and clean gases) and new technologies (e.g. CCUS technologies and hydrogen-based steel) would only be leveraged after 2030. Also, a complete vision for a higher value-added circular economy is missing: this needs to start at the products level, creating the right conditions for truly sustainable lifecycles, e.g. with more durable products. The narrow focus on energy efficiency improvements combined with limited fuel switches between now and 2030

leads to modest reductions in GHG emissions compared with other sectors and other scenarios (-23% to -26% compared to 2015).

- With respect to the **agriculture**, the IA focuses primarily on technical measures although it acknowledges the co-benefits of improving diets. The importance of reducing meat consumption and livestock numbers cannot be overstated given its impact on the whole value chain: it reduces pressure on production intensification and releases land for new forests or grasslands. This is not simply a lifestyle issue but requires instead fundamental innovation in the food production system with new alternatives to meat. Moreover, the IA suggests almost doubling the consumption of liquid biofuels by 2030 by mainly relying on dedicated energy crops which may raise sustainability risks without clear safeguards. Consequently, regarding **LULUCF**, the IA clearly does not significantly expand natural sinks before 2030 compared to the CTI scenarios.

CONTEXT AND OBJECTIVE OF THIS REPORT

THE EU IMPACT ASSESSMENT ANALYSES POLICY PACKAGES TO RAISE THE EU 2030 CLIMATE TARGET TO -50% TO -55%

The EU Commission has just published its communication "Stepping up Europe's 2030 climate ambition" and related Impact Assessment (IA) on raising the 2030 target (European Commission 2020a,b,c). Taking its responsibility in achieving the Paris Agreement, the IA discusses options to increase the EU-27 2030 GHG emissions reduction target and the necessary adaptation of the policy framework to reach higher targets. In its Communication the Commission proposes to increase the target to 55% and highlights the need for a combination of policy levers including the extension of the ETS which is in line with MIX-scenario.

More specifically, the IA lists available policy packages in each sector which would lead to increased emissions reduction. Five scenarios of increased 2030 targets are then proposed by combining these policy packages and compared to a baseline projection of the emissions under the current policies. Three of these scenarios reach -55% emissions in 2030 compared to 1990, when including Land-Use, Land-use changes and Forestry (LULUCF) and excluding international bunkers:

- The **REG** scenario builds on intensified policies and regulations;
- The **CPRICE** scenario drives the implementation of mitigation actions by increasing the carbon price and extending the carbon pricing mechanism to buildings and road transport.
- The **MIX** scenario also reaches -55% emissions reduction by 2030 by combining some intensification of the policies (but softer than in the "REG" scenario) and extending the carbon pricing to buildings and road transport.

Another proposed scenario is limited to -50% in 2030 (the "**MIX-50**" scenario) for the same scope while a "**ALLBNK**" scenario reaches -57.9% in 2030 when including all international bunkers (aviation and maritime transport).

In its IA, the Commission also explores a **major shift in policy architecture**: the extension of EU-wide carbon pricing to buildings and road transport. Concretely, it examines the following options:

- Current scope of EU ETS and ESR (ETS_1)
- Extension of current EU ETS (ETS_2) with the following variants:
  - Newly covered sectors do not remain in the ESR (ETS_2.1)
  - Newly covered sectors remain in the ESR (ETS_2.2)
- Separate EU-wide emissions trading system for new sectors (ETS_3)
- Obligatory carbon price incentives through national systems (ETS_4).

These scenarios were designed and assessed using the EU Commission modelling suite, which covers the entire economy and quantifies impact on the energy system, transport, agriculture, forestry and land use, atmospheric dispersion, health and ecosystems, macro-economy with multiple sectors, employment and social welfare.

THIS REPORT COMPARES THE IA WITH RESULTS FROM THE CTI MODEL AND LITERATURE TO INFORM DECISION-MAKERS ABOUT THE FULL RANGE OF MITIGATION OPTIONS

The objective of this report is to support the EU decision makers and Member States in better understanding the implications of the IA scenarios and discussing potential alternative options for reducing emissions. Given the short time frame available for this analysis, the briefing is necessarily limited in scope and depth. Its main aim is to highlight key points where the Commission diverges from other studies, proposing avenues for strengthening future analysis.

First, the briefing compares the three IA scenarios reaching -55% by 2030 (including LULUCF) to the two EU CTI scenarios reaching -55% (excluding LULUCF) published by CLIMACT in June 2020 (CLIMACT 2020). These alternative scenarios were designed using the CTI 2050 Roadmap Tool, a transparent simulation model of total EU GHG emissions.

The two CTI scenarios differ from each other in terms of preferred principles to reduce emissions:

- The ***55% Technology-focused*** *s*cenario deploys technologies much faster than the current pace. This includes upscaling mature technical solutions and accelerating the development of those currently at lower Technology Readiness Level. This technology-focused scenario demonstrates what can be achieved without fundamentally changing today's lifestyles, while raising deployment, infrastructure, innovation and R&D challenges.
- The ***55% Shared Effort*** *s*cenario reduces the effort on some technological developments but includes more action on lifestyle and socio-cultural changes (modes of travel, including fleets of shared vehicles, healthy diets, consumption and production patterns, etc.). These societal changes require certain infrastructure deployments but reduce the need for other capital investment and infrastructure, as well as the total cost of the energy system (and energy bills for EU citizens). This scenario leads to higher co-benefits, for example regarding health, biodiversity, landscapes and ecosystems but leads to stronger shifts in industrial activity from traditional to new industries.

In order to align its emissions accounting with the UNFCCC scope, the IA target covers all the emissions and sinks by the LULUCF sector. LULUCF represents a net CO_2 sink of 294.6 $MtCO_{2e}$ in 2015 (i.e. ~7% of the emissions from the other sectors). The CTI scenarios however were designed excluding the LULUCF sector in accordance with the current EU target scope. The IA and CTI scenarios thus should be compared with care as their 2030 ambition significantly differ (the CTI scenarios reach around -60% in 2030 compared to 1990 when including LULUCF). This report focuses on the sectoral ambition and the interactions between the sectors.

A WHOLE SYSTEM VIEW ON POLICY LEVERS AND CROSS SECTORAL LINKS

Options for transforming the EU climate policy architecture

The IA discusses several options for strengthening the EU climate policy architecture in 2021. The main aim is to explore how EU-wide carbon pricing could be extended to two new sectors which are currently not subject to the EU ETS: road transport and buildings.

This briefing discusses the IA's major findings and arguments and compares them to the findings of the relevant literature, to identify blind spots that require closer attention and additional analysis in the future. It is not the aim of the briefing, however, to discuss the strengths and weaknesses of different carbon pricing options *per se* (for a detailed recent overview see Matthes 2020 and Stenning 2020). In general, it has become clear that a high enough carbon price can be a forceful tool to deliver rapid emission reductions and to support structural changes in the key emitting sectors – as evidenced by the decline of coal-fired power generation in 2019 and 2020, for which the rising CO_2 price from the EU ETS was a major factor. However, it is also clear that due to the regressive effect of carbon pricing, any new system targeting the buildings and road transport sector needs to be very carefully designed to compensate negative distributional impacts and avoid undue hardships.

After discussing implications based on the modelling results and reflecting on potential benefits and risks, the European Commission expresses a recommendation for exploring the extension of the current EU ETS to the buildings and road transport sectors (ETS_2), while leaving open what should happen to the ESR. A separate trading scheme for new sectors (ETS_3) is presented as a potential temporary solution to test trading for buildings and road transport without impacting the sectors already covered under the existing EU ETS.

The Commission's main argument for extending the ETS is the security of reaching emission reductions in line with the climate targets while generating government revenues for climate action or for addressing distributional concerns. The cap of an extended ETS would cover the vast majority of EU emissions and would thus create a harmonised incentive for all covered entities to reduce their emissions in line with the target. The IA further mentions that, unlike other instruments, carbon pricing would be able to address rebound effects from energy efficiency improvements through internalising carbon costs in end user prices. Moreover, the IA modelling shows that intelligent recycling of these revenues can generate macroeconomic benefits (by addressing distortions resulting from labour taxes). Alternatively, revenues can be used to compensate for the instrument's regressive effect (e.g. through lump sum payments to households).

WHILE PROPOSING TO EXPLORE THE EXTENSION OF THE EU ETS, THE COMMISSION RECOGNISES THE NEED FOR STRENGTHENING REGULATION AT THE SAME TIME

At the same time, the Commission acknowledges that carbon pricing alone will not be sufficient to reach the 2030 target. Several market failures and barriers, including non-financial barriers, bottlenecks in capacity and infrastructure and other factors impede decarbonisation, in particular in the building sector, but not only there. An additional problem is that price sensitivities vary enormously between the different sectors: in particular in road transport and heating, the combination of other barriers and market failures and the demand structure result in low price elasticities, meaning that high carbon prices would be needed to affect demand. As a result, a carbon price that is high enough to drive changes in transport could cause undue hardships particularly for low-income households and some businesses if distributional effects or level-playing field are not properly addressed (see Stenning 2020).

Recognising these challenges, the Commission argues that a mixed approach which combines carbon pricing in the non-ETS sectors with strengthened regulatory instruments such as standards can avoid peaks of the carbon price, and the resulting burden on households and some businesses. This finding is in line with extensive scientific evidence on **the strengths of policy mixes** compared to a pure pricing approach (Matthes 2020, Görlach, 2014): while the carbon price can be a powerful driver in the transformation towards climate neutrality, there is also a clear **need for companion policies** that address the plenitudes of **non-market barriers and market failures** that impede the transformation – and which are even more prevalent in housing and transport than they already are in energy and industry . It is therefore to be welcomed that the Commission clearly prioritises the MIX scenario over the CPRICE scenario where the extended ETS is the main instrument.

A POLICY MIX IS WARRANTED FROM A RISK MANAGEMENT PERSPECTIVE

Given the administrative challenges arising from this systemic shift, a multi-instrument approach seems warranted from a risk management perspective. The IA discusses the administrative challenges arising from the need to secure and monitor data for an upstream trading scheme and potentially from combining the new system with the existing downstream trading in the EU ETS. While manageable according to the IA, the implementation will still require a careful and probably time-consuming process. For this reason alone, it appears prudent to maintain and strengthen regulatory measures, as planned while the new approach is being put in place.

The political challenges are not the focus of the IA. Yet, in the negotiations a number of concerns are likely to emerge.

- First, Member State governments may fear carbon price spikes: as ambition increases, the carbon price would need to ensure that emissions remain within the cap. A rising carbon price could drive up prices of heating fuels and electricity in particular, **but it could also affect the competitiveness of industries already covered under the existing ETS – unless effective**

protection can be achieved e.g. through the envisaged border carbon adjustments (see Stenning 2020 for a quantitative analysis). Properly addressing distributional aspects is of central importance for acceptance of any carbon pricing system (Agora Energiewende 2019). **Unmitigated regressive effects would create a risk for the acceptance of EU climate action**, particularly when exploited by EU-sceptic groups. The IA does not provide any detailed analysis of this crucial issue, since it does not discuss design variations in any detail. This will be a key task for the instrument-specific IA.

- **This also applies to the distributional effects between Member States**. In an extended ETS, it would be purely down to market forces to determine how much reduction takes place in which sector and in which Member State. In the logic of minimising overall abatement costs, the determination where emissions are reduced would be the result of the marginal abatement costs of different emitters, and their willingness and capacity to pay. This is already the case in the current EU ETS, where a Finnish cement plant receives the same treatment as a Portuguese one. Yet it marks a significant departure from the current ESR, where the effort distribution is politically negotiated on the basis the capacity to mitigate emissions (with GDP per capita used as a proxy). In an EU ETS with broad sectoral coverage and a discontinued ESR, such politically negotiated outcomes would no longer be feasible for the distribution of mitigation efforts. They would, however, be possible regarding the distribution of revenues which is poised to be controversial and at the same time crucial for the acceptance of the overall approach. Some form of solidarity mechanism will likely be necessary to reflect discrepancies in Member States' wealth as it is already the case in the EU ETS with the Modernisation Fund. Öko-Institute and Agora Energiewende (2020) have already proposed **solidarity allocation mechanisms for a revised ESR that might be redesigned to fit into an extended EU ETS.** This element is not assessed in the IA which does not provide any analysis on disaggregated impacts per Member State, because – according to the Commission – discussion with Member States about the new EU Reference Scenario are still ongoing as is the in-depth analysis of final National Energy and Climate Plans (NECPs).
- Finally, Member States need to reconcile any new EU-wide approach with existing national measures to price carbon or fossil fuel-based energy use in the non-ETS sectors while ensuring that additional incentives for GHG mitigation arise – another element that is not discussed in any detail in the IA.

All of the concerns mentioned above may lead to design choices for the new or extended scheme that would reduce its overall effectiveness, e.g. the introduction of exemptions or price ceilings. As the example of the EU ETS showed, it took several rounds of simplification to abolish the numerous exemptions, detailed and generous rules for free allocation of allowances or scope limitations that Member States had introduced in recognition of the specific circumstances of their domestic emitters. **This again underlines the need for a risk-based approach based on a combination of instruments.**

SHARED RESPONSIBILITY BETWEEN ETS AND ESR REDUCES RISKS AND CAN HAVE SIGNIFICANT BENEFITS FOR STEERING ECONOMY-WIDE TRANSFORMATION

An open question concerns the future of the ESR in the new climate policy architecture**.** In principle, it would seem logical that as the EU ETS grows, the domain of the ESR shrinks, relegating it for waste and small industrial emitters, if emissions from agriculture are integrated in a new sector together with LULUCF emissions. The IA rightly points out that once a trading system is in place in the new sectors, it would be inefficient to force two different parties (i.e. national governments as well as the actual emitters) to reduce the same emissions. Indeed, it appears difficult to imagine – even from a legal standpoint – how the sanctions for exceeding national ESR budgets could be maintained if private actors are free to trade their non-ETS allowances with private actors in other Member States.

However, such overlaps are not fully without precedent. In the complex interactions between national and EU level climate governance**,** several countries have defined emission reduction targets or even budgets for sectors that are covered by the EU ETS. This has been the case for example in the UK where a carbon budget covers the entire economy and therefore included UK ETS emissions and in Germany where a national sector target exists for the power sector. In these cases, no financial sanctions apply, and it is not the case that two EU-level regulations conflict with each other. Nonetheless, it shows that **different actors can be assigned responsibility for reaching reductions targets in the same sectors** of the economy**. A similar sharing of responsibility could also be envisioned for the ESR and an extended EU ETS** – in particular since the final carbon pricing instrument may not be a textbook trading system, e.g. if it includes a ceiling price for heating and transport. In any case, national governments would still have an important role in designing and implementing most other elements of the policy mix, i.e. the companion policies that reduce barriers and imperfections, and drive change where the carbon price cannot.

In such an overlapping system, the ESR and ETS would take on different functions: **the role of the ESR would be to provide long-term guidance and orientation,** including for investors. It would ensure that national governments adopt and implement climate policies that address the transformation to climate neutrality as a systemic challenge, and that support private actors in their mitigation efforts, e.g. by rolling out the supporting infrastructure and the regulatory framework, and supporting technology development. **The role of the ETS, by contrast, would be to discover and mobilise the least-cost abatement potential** that is already available and market-ready across the economy, and incentivise citizens to take into consideration carbon emissions when making consumption or investment decisions.

While such an overlapping system might not be economically optimal, it seems warranted from a risk management point of view. At least as long as a carbon pricing scheme for road transport and buildings emissions is not in place and has not proven effective yet, it would be extremely risky to toss out the functioning system of compliance control that is the ESR. In the existing EU ETS, except for a brief spell in 2008/2009, it took 15 years and several rounds of reform until the system has now finally become capable of delivering a carbon price that has a noticeable effect on emissions. At this point in time, the EU no longer has the luxury of taking so long to experiment, fail and eventually improve.

Recognising the interdependence across sectors

It is important to ensure that policies address the interdependence between the various sectors of the economy.

ELECTRIFICATION BASED ON DECARBONISED POWER IS NEEDED FOR REDUCING BUILDINGS AND ROAD TRANSPORT EMISSIONS

Power is one of the cornerstones of the decarbonisation of the demand-side sectors, particularly in transport and buildings, and it has the potential to be decarbonised quickly. The CTI model identified an emissions reduction potential of over 90% by 2030, while the -55% scenarios in the IA reach in the order of -70% reductions by 2030, with gas-based electricity production keeping an important share of the mix. **Policy-makers must not only incentivise a fast coal phase-out but also ensure gas reduces quickly.** At the same time, the electrification of the transport and buildings sectors must be thought through to support grid stability with demand-side management and storage solutions.

EMBRACING ALL ASPECTS OF THE CIRCULAR ECONOMY IS A KEY LEVER FOR LOW-CARBON TRANSFORMATION

The circular and sharing economy has the potential to transform all sectors and has been shown to be another cornerstone of a sustainable low-carbon transition, while also contributing on other dimensions such as material use, waste management, etc. **Efforts on the demand side and the quality of the products trickle down all the way to the industry value chain and to the supply side.** To maximise the potential, policy-makers need to design a comprehensive set of policies to be applied well before 2030. A series of options exist to use products and materials much more efficiently, extending their lifetimes and ensuring their extended use, sharing, reuse and refurbishments. The associated challenges in product design, production and maintenance, as well as changes in the business model will be significant for many types of assets, from cars, houses, appliances, waste streams to energy. These transformations can help not only to reduce GHG emissions but also to make our economies much more resilient to shocks as our assets will be built to last longer and new local jobs will be created. However, these transformations will also have profound impacts on the way we live and consume as well as on employment, implication that need to be fully addressed in the policy mix.

The IA acknowledges that the transition to a circular economy enables further GHG emission reductions. However, the Commission considers that additional research is needed to quantify the measures' climate impacts before they can be integrated in the Commission's modelling framework**.** The scenarios modelled in the **CTI highlight the importance of tackling a circular economy right**

away, leading to significant reductions in material use already by 2030 (some basic materials consumption can be reduced up to -8% to -25%) and with the wide range of measures having further impact in the following decades.

BIOENERGY IS ONLY SUSTAINABLE WHEN TAKING A WHOLE-SYSTEM PERSPECTIVE

Sustainable bioenergy can play a limited role in reducing emissions when other decarbonisation technologies are not yet available. This however is only credible if combustion emissions are fully offset by carbon capture during the biomass growing phase. The CTI handles bioenergy very carefully by limiting the bioenergy needs and ensuring the related feedstock are mainly coming from residues and by-products from agriculture and the wood industry. The IA suggests a strong increase of the liquid biofuels supported by dedicated energy crops which prevents extending natural sinks such as forests or grasslands before 2030. These two approaches demonstrate why other zero-carbon solutions must be rapidly deployed: policies that ensure R&D in transport, industry and buildings will allow bioenergy requirements to remain at a sustainable level.

TECHNOLOGY-FOCUSED SCENARIOS RAISE OTHER RISKS WHICH DESERVE CAREFUL ATTENTION

As described in the sectoral deep-dives below, the IA scenarios as well as the CTI technology-focused scenario reach their 2030 target by assuming limited societal and lifestyle changes such as shifts in diets, reductions in travel demand or the consumption of products, as well as the establishment of strong circular economy principles. They leverage instead a fast deployment of technical solutions which may in turn limit the decrease in production of basic materials (although no information is available in the IA scenarios on the evolution of the levels of industrial production or material demand).

The IA and the CTI scenarios focus on analysing scenarios in terms of GHG emissions, energy consumption, land use and other emissions drivers. However, other sustainability issues deserve careful attention since large-scale technological development may potentially raise risks such as:

- Excessive consumption of raw material resources, demanding large resource extraction;
- Biodiversity degradation from the extraction of these minerals as well as the increased use of agricultural entrants;
- Inertia in infrastructure and consumption patterns which would not be sustainable in the longer term (lock-in);
- Limited social acceptance of large-scale infrastructures and renewable energy plant, and potentially adverse impacts on land use and biodiversity.

COST IMPLICATIONS VARY DEPENDING ON THE MODELLING APPROACH

This study did not compare the IA costs implications to the CTI scenarios ones since the underlying models differ from each other in terms of costs assumptions. The CTI scenarios however demonstrate how a pathway including lifestyles improvement and circular economy leads to a reduction of the total energy system costs. Cost differences are stronger after 2030 once the demand-side measures implemented before 2030 deliver their full benefits. The reduction in cost comes from lower annual fuel costs, but also from requiring less investment based on better asset utilisation. This is typically the case in transport where the trend to use vehicles as a fleet rather than owning them privately can be reinforced. A more technology-oriented scenario, such as the CTI *55% Technology-focused Scenario*, requires more investment until 2030 (+51% investment in 2030 compared to 2016, up to €1,076 bn in this model) which then permits avoiding fuel cost increases (see Figure 1).

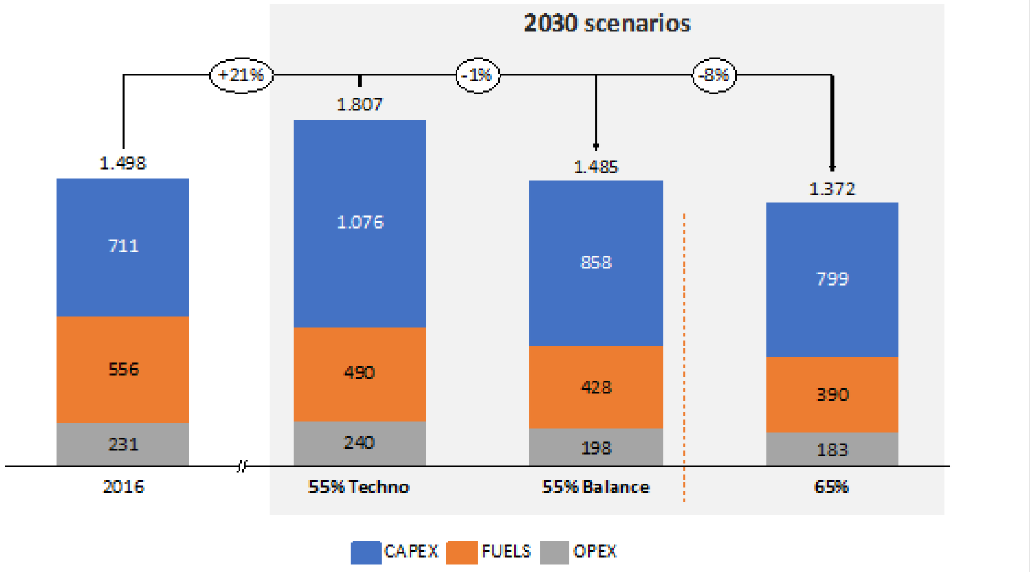

Figure 1: Total energy system costs in 2016 and in 2030 in the CTI scenarios [bn€]

ANALYSING SECTORAL AMBITION IN THE IMPACT ASSESSMENT

Overview of emissions reduction by sector

Before deep diving in the detailed sectoral implications, the following table provides an indicative comparison of the emissions reduction per sector in the compared scenarios even though the emissions scope may slightly differ between the models.

The IA scenarios clearly bet on a profound shift of the buildings sector with emissions reduction levels significantly higher than in the CTI scenarios. The emissions reductions are relatively comparable for the industry and agriculture in the two sets of scenarios even though the selected measures differ (see sector details below). The transport sector clearly bears less effort in certain aspects of the transition in the IA scenarios compared to the CTI ones, which also push the power decarbonization further addressing the gas phase-out on top of the coal phase-out.

	Selected IA scenarios			Selected CTI Scenarios	
Sectors	REG	MIX	CPRICE	55% Technology	55% Shared Effort
Buildings	-63.6%[a]	-62.0% [a]	-61.0% [a]	-22.4% [b]	-25% [b]
Industry[c]	-23%[g]	-23% [g]	-24% [g]	-25.5%[h]	-27% [h]
Power production	-69.6%	-70.8%	-70.4%	-85.5%	-92%
Transport[d]	-17.6%	-16.3%	-15.6%	-46.4%	-37%
Agriculture & Waste	-31.0%[e]	-31.0% [e]	-31.0% [e]	-29.3% [f]	-33% [f]

Table 1: Overview of the emissions reduction by sector in 2030 compared to 2015.

Notes: (a) Residential sector only; (b) Residential and non-residential buildings; (c) Including process CO_2 emissions from industry, excluding refineries; (d) Excl. International bunkers; (e) Non-CO_2 emissions, excl. Energy consumption from agriculture; (f) all emissions from agriculture and waste, incl. Energy consumption; (g) Including refineries; (h) Including oil & gas.

Power

Decarbonising energy supply is essential in reaching higher EU climate targets. This is particularly true for the power sector as electrification will drive decarbonisation only with clean electricity. GHG emissions from the power sector accounted for 28% of total EU emissions in 2017. They fell 12% in 2019 compared to the previous year, they remain one of the largest emitting sectors in Europe.

Power sector emissions went down by -32% in 2019 compared to 2012 due to a decrease in coal and increase in renewable energy production. This increase in renewable energy sources has recently slowed, going up by 16% per year on average between 2010 and 2017, but increasing only by 6.5% in 2018 and +5.5% in 2019 (Agora Energiewende 2020b).

Key components across all scenarios are the deployment of renewable energy and a coal phase-out by 2030. We find that the scenarios in the IA go in the same direction as the ones modelled by CLIMACT. The IA results are roughly aligned with the CTI Technology-focused scenario with a ~11 to 13% increase in electricity demand, and with wind and solar generation doubling or tripling in size over the next 10 years to enable the coal phase-out without leading to a massive increase in gas-based electricity production.

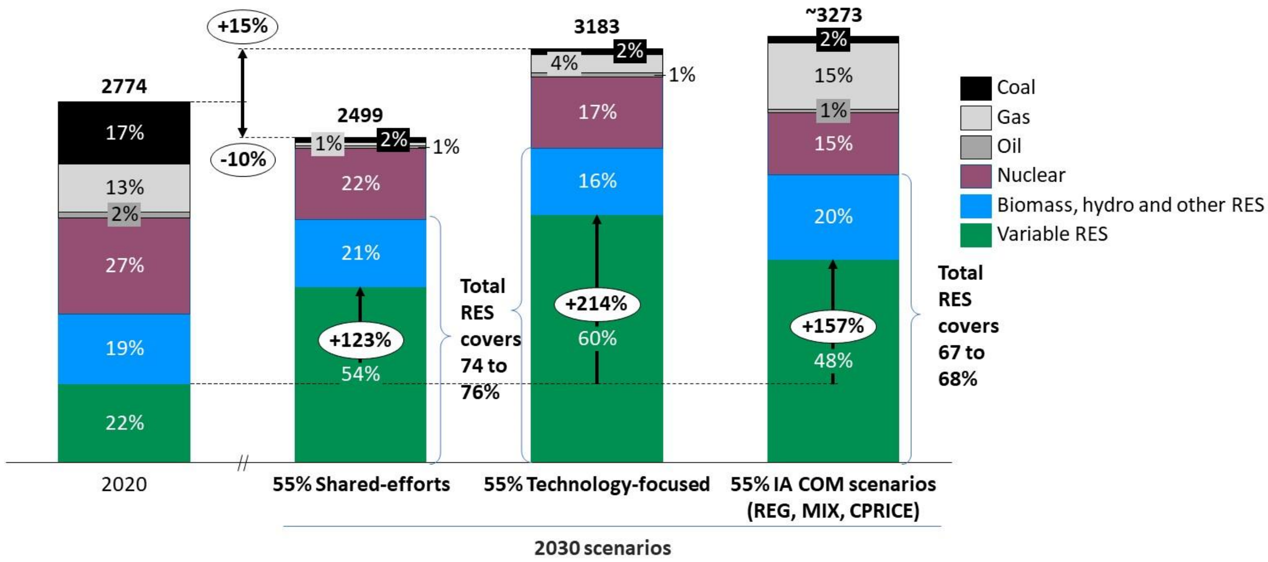

Figure 2: Power generation (TWh) in the two CTI scenarios and the IA scenarios (estimates)

However, the Commission's scenarios still see 17 to 18% of electricity produced based on fossil fuels (the exact mix between coal, gas and oil is only inferred based on total final demand for coal of 115 TWh, so potentially ~50 TWh net electricity production). This means gas remains one of the main components of the electricity mix, and therefore other sectors such as the LULUCF sector will have to contribute more towards the 55% target.

The increase of renewables in electricity generation should be incentivised through "more ambitious renewables policies and/or a further increase in the ETS carbon price" (European Commission 2020b, p. 54). The results for the policy scenarios show that the effects are quite similar for an increased carbon price or more ambitious renewable policies as both have almost the same renewable share. This might be a result of keeping the existing renewable policies and the ETS in both policy scenarios REG and CPRICE. The difference is that electricity consumption is slightly higher in the CPRICE scenario when compared to REG because more power is used in buildings whereas REG priorities efficiency.

However, specific challenges in the built-up of renewables certainly need an improvement of regulatory frameworks e.g. in regard to simplification and alignment of administrative, planning and permitting procedures and facilitated market and network access while a higher carbon price pushes renewables competitiveness and reduces the required public payments for their deployment (see e.g. Löschel et al., 2020; Agora 2019). At the same time, a better framework for renewables reduces the need for fossil fuels.

The IA shows that all policy scenarios **REG, MIX and CPRICE are fairly similar with a drastic reduction of fossil fuel electricity generation from coal in particular**. The Commission is aware of the need to **urgently address the substantial challenges that will result for coal-dependent regions** and discusses policy actions building on existing initiatives like the Just Transition Fund, the Coal Regions in Transition Platform and skill training. At the same time, it is not entirely clear if the EU ETS alone can ensure the coal phase-out as non-economical barriers exist. An potential policy option to consider would be a EU funding for managing the transition in coal regions is conditional on national phase-out plans (CAN Europe and Sandbag 2019).

Transport

The ambition significantly differs between IA and CTI scenarios. Total IA GHG emissions of inland transport (excluding aviation and marine) are forecasted to be around 600 Mt CO_2 for all three scenarios, while the CTI scenarios are more ambitious and reach 540 Mt CO_2 and 460 Mt CO_2 for the Shared Effort and Technology scenarios, respectively. This difference in ambition is reflected in all activity level changes as detailed in the Annex.

THE TRANSPORT DEMAND GROWTH IS MAINTAINED IN THE IA SCENARIOS

As it can be seen on Figure 3, one key difference between IA and CTI scenarios lies in the evolution of both passenger and freight transport demand. The CTI scenarios investigate complementary pathways where the current growth rate of freight and passenger transport demand are curbed from 2015 to 2030. [1] This is a strong shift compared to the current observed growth in this sector which is the only one that experienced an increase in emissions since 1990. IA scenarios therefore propose

[1] Passenger transport demand in the CTI scenarios is either stabilised (Shared Effort) or slightly increasing (Technology, +7% by 2030 compared to 2015), while IA scenarios foresee an 18-20% increase in transport demand. Freight transport growth between 2015 and 2030 is limited to 7% and 20% in the CTI Shared Effort and Technology scenarios respectively, while IA scenarios foresee an increase from 30 to 33% over the same period.

trajectories maintaining the historical growth. This preserves activity for the current automotive industry, but also leads to technology shifts which are difficult to reach.

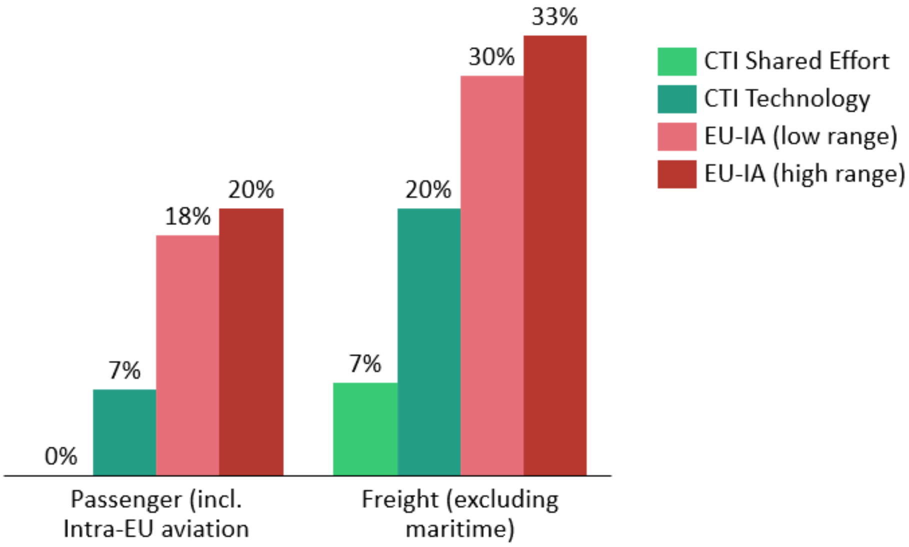

Figure 3: Growth of passenger and freight transport demand in CTI and IA scenarios (estimates), 2015-2030

The second main gap between CTI and IA scenarios concerns the modal split. Both types of scenarios foresee a shift from road to rail (passenger) and from road to rail and navigation (freight). In the CTI scenarios, this shift, coupled with a curbed transport demand, allows to increase the share of these softer transportation modes and to decrease the share of road transport. In the IA scenarios however, the increase of rail and internal navigation activity rather absorbs the increase of the overall transport demand than decrease the road transport activity.

Changing transport demand patterns with a higher modal shift to public transport and wider penetration of sharing options **could complement technology shifts.** These patterns will be affected by a **wide variety of societal factors, some of which can be more easily influenced by policy-makers than others.**

THE TECHNOLOGY SHIFT IN THE IA IS COMPLEMENTARY TO THE CTI MODAL SHIFT

Alternative fuels and powertrains play an important role in all analysed scenarios. The technology shift towards alternative powertrains (e.g. BEV) is similar in relative terms in IA and CTI Shared effort scenarios, with Zero and Low Emission Vehicles (ZLEV) reaching 21% to 25% of in the car fleet by 2030. The CTI Technology scenario on the other hand explores a much larger uptake of these alternative powertrains (41% of ZLEV in the car fleet by 2030). Yet, these figures should also be compared in their absolute values. The CTI scenarios foresee a stabilisation and a 40% decrease of the EU car fleet for Technology and Shared Effort scenarios respectively between 2015 and 2030. By contrast, IA scenarios foresee an increase of the passenger road transport demand, which is likely to increase the car fleet as well. Hence, the absolute amount of EVs in the fleet might be significantly larger in the IA than in CTI scenarios.

The IA scenarios are also betting on a more important contribution of biofuels to decarbonisation as the biofuel quantity they foresee is approximately twice as high as it is in CTI scenarios (between 230 and 290 TWh for IA scenarios vs 128 TWh in CTI scenarios). The IA does not mention how this biofuel demand is split between the different modes and solely mentions that aviation and navigation are driving the increase of biofuels. Hence, it cannot be excluded that biofuels are also foreseen to play a significant role for inland modes as well.

Finally, IA scenarios mention digitalisation and smart traffic management as enablers of sustainable urban mobility. This can be connected to the mobility-as-a-service concept that affects the utilisation and occupancy of private cars. However, these measures are not quantified in IA scenarios, thereby preventing the comparison with CTI scenarios.

IT IS POSSIBLE TO ACCELERATE THE TRANSITION IN TRANSPORT WHILE IMPROVING QUALITY OF LIFE

IA transport scenarios are a positive step towards reaching net zero emissions in 2050. However, the analysis above shows that considered measures mainly belong to technological solutions. This may result in an increased demand for raw materials for new vehicles and a biofuel demand hard to satisfy in a sustainable way. Furthermore, focusing solely on technological solutions is a missed opportunity to fully reap the fruits of a balanced mobility transition, where a controlled transport demand and an ambitious shift to softer modes can bring many co-benefits in terms of air quality, health and quality of life for EU citizens.

From a policy perspective, the Commission highlights the need for a shift to clean and efficient mobility options including walking and biking. The highlighted mix of policy instruments including the extension of the ETS to road transport, existing taxation and CO_2 standards for vehicles "are complementary instruments, acting as incentives on the fuels use and on the introduction of technologies respectively." (European Commission 2020b, p.146f.). This is somewhat in line with e.g. Agora Energiewende (2020a) arguing that **even if road transport emissions are included into the ETS, there is still need for regulatory measures since the willingness and ability to pay is much higher in road transport when compared to the power sector or industry**. In addition, private and commercial consumers are not always fully aware of the financial consequences which means that measures targeting the purchasing of vehicles can be more effective (see e.g. Velten et al. 2019). In this context, the Commission could be clearer in communicating that a phase-out of fossil-fuel based vehicles is urgently needed between 2025 and 2040 the latest – depending on the assumptions (e.g. Agora Energiewende 2020a; DLR 2019).

Following above described developments of passenger and freight transport volumes, it is also important to strengthen the role of clean, non-motorised mobility and the need for stabilising the overall need for mobility. In this context, the Commission does not provide a real approach but rather refers to a new initiative on “Sustainable and Smart Mobility’” (European Commission 2020a, p.13). Yet, the 2016 Mobility Strategy already highlighted the need for zero-carbon mobility but current and outlined developments in the IA do not show a substantial shift. Thus, more and comprehensive action is needed to address the challenges in transport (see e.g. CLIMACT and NewClimate 2020).

Buildings

The scenarios suggested in the COM IA are more ambitious in terms of GHG emission reductions by 2030 than most of the studies carried out so far. Targeted emission reductions are mainly enabled by a **quasi-full phase-out of liquid and solid fossil fuels.** This suggests a strategic shift by the European Commission as it contrasts with the “energy efficiency first” principle with the Commission concluding that "fuel switch in heating in buildings is the key avenue for buildings to contribute to an increased 2030 climate target”.

The exact assumptions underlying the modelled policies are difficult to grasp. However, based on the reported content, it seems that energy efficiency improvements of buildings envelopes are mainly driven by cost-efficient investments – and supported by actions to mitigate market failures – while the deployment of RES heat is driven by financial incentives beyond the impact of a carbon price on the business case of these investments. At the rise of the start of the Renovation Wave, this sounds like an early defeat on a real boost of the renovation activity in the required rate towards high-efficiency and carbon neutral buildings by 2050.

While the ambitions in terms of annual rates of deep renovations remain on the rise compared to the historical average, they do not reach the 3%/year required to transform the entire building by 2050. The number of one-stage deep renovations also remain very low.

The signal for the 2030 GHG target is positive, however further efforts to improve the annual renovation rate beyond 2030 will be required. Not only to improve the quality of life and the resilience of European citizens, but also to reduce the magnitude of the changes of the energy system needed to decarbonize the heating and cooling of buildings. More details can be found in the next paragraphs.

SIGNIFICANT UPWARD REVISION OF BUILDINGS TARGETS COMPARED TO THE EU LONG-TERM STRATEGY

The IA significantly increases previous ambitions for the building sector; making them much more forceful by 2030 than suggested in CTI scenarios. This is the sector for which the reductions are the largest in IA: the newly proposed scenarios supporting the EU -55% vision suggest a need to reduce emissions in the buildings sector by 60% by 2030 compared to 2015. This is three times more than modelled in the EU Long-term strategy aiming at -18% reduction in that sector in 2030 before reaching global neutrality in 2050 (European Commission 2018).

EFFICIENCY IMPROVEMENTS IN THE IA RESULT FROM A CONSERVATIVE INCREASE OF THE RENOVATION RATE AND AN AMBITIOUS RENOVATION DEPTH IN LINE WITH CTI FINDINGS

The growth in renovation rates – as well as the depth of renovations – as modelled in the new IA scenarios is important, increasing the energy efficiency of buildings and hence reducing energy demand. **It is encouraging to see that the most ambitious renovation ambitions (for residential) are similar in the CTI and IA scenarios** (see Annex). For example, the REG IA scenario aims for an average renovation rate of 2.4% per year between 2026 and 2030 – with energy savings ranging from 50% to 66% (on average, over the same period). Ambitions are however much stronger in CTI for non-residential buildings, particularly in terms of renovation rate where CTI scenarios target 1.9%/year of renovations rate as of 2025 and 2.5%/year by 2030 whereas IA ambitions maximum 1.5%/year on average for the 2026-2030 period. Those rates are not sufficient to renovate all buildings (at least 3%/year of renovation rate needed to renovate 90% of the housing stock by 2050), which explains the increased ambition in fuel switch detailed below.

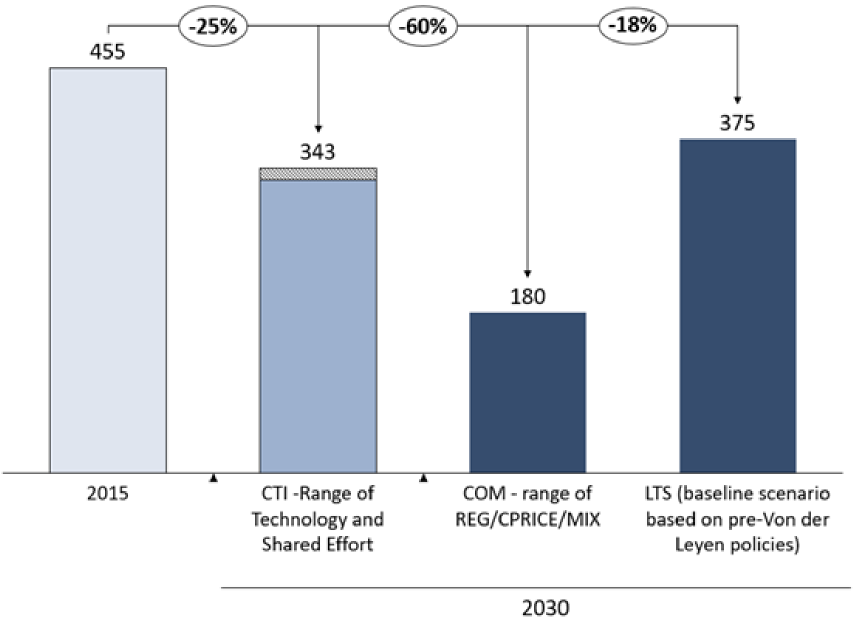

Figure 4: GHG emissions for residential and non-residential buildings (m t CO_{2e})

MOST OF THE EMISSION REDUCTIONS ARE REACHED THANKS TO A QUASI-FULL PHASE-OUT OF LIQUIDS AND SOLIDS FOSSIL FUELS IN TEN YEARS

The contrast between the CTI modelling and the IA scenarios is mainly due to very distinct ambitions in terms of fuel switch. **IA targets a quasi-full phase out of liquid and solid fossil fuels by 2030.** It is this lever that, by reducing the carbon intensity of the heat, allows for the additional reduction of emissions compared to the CTI scenarios – since the renovation ambitions are similar. In the three -55% scenarios of the Commission, the consumption of coal and liquid fossil fuels becomes marginal (coming from roughly 16% in 2015). Even if still significant by 2030 (23%), gas consumption is reduced by 43% compared to 2015, i.e. a total of 523 TWh in 2030, compared to 594 TWh for the CTI-Shared

Effort scenario and 930 TWh in 2015. Additional energy savings beyond 2030 seem key when looking at the availability of low-carbon gas to further decarbonise heat. The European Commission flags low-carbon gas as an important part of the strategy beyond 2030 while the gas sector reports 230 TWh available for buildings by 2050 (Gas For Climate 2020).

In the new ambitions, fossil fuel consumption represents only ~26% of the total mix, compared to 49% in 2015, an absolute reduction of ~815 TWh (-58% compared to 2015). This is 26% better than the CTI-Shared Effort scenario (whose energy mix remains similar to 2015 in relative terms and which reduces fossil fuel consumption by 442 TWh).

These decreases are allowed thanks to a much higher intake of electricity consumption (mainly corresponding to heat pumps) and renewable energies than in the CTI scenarios (which roughly stagnate in relative terms compared to 2015 while electricity consumption rises from 640 to 872 TWh in the IA scenarios). "Yearly consumptions" indicators can hide part of the difficulties: technical challenges associated with, for example, winter peaks will have to be anticipated and tackled (through smart control and demand-side management solutions) to make this transition feasible.

While the majority (60%) of emissions are reduced by 2030 in the IA scenarios, there is still 40% to be achieved. Renovation efforts will have to be maintained and even increased to reduce the pressure on the power sector and ease the transition in sectors where energy efficiency gains are more complex to achieve. This is reflected in the CTI scenarios, which project a 60% decrease in residential energy consumption in 2050 (compared to 2015), while the most ambitious IA scenario (REG) shows only 36% of reductions for the same period.

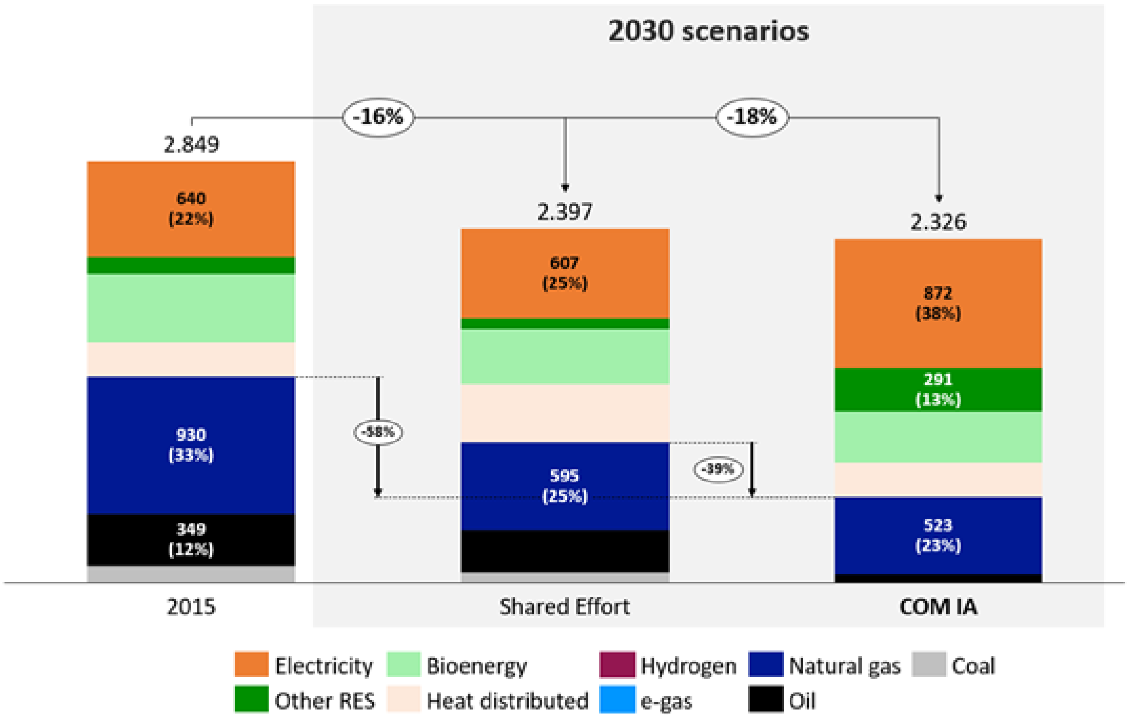

Figure 5: Residential final energy demand in CTI-Shared Effort and IA scenarios (in TWh), 2015 vs. 2030

The Commission proposes a mixed approach to address buildings GHG emissions. The IA (European Commission 2020b, p. 71) finds that using only a carbon price (CPRICE scenario) incentivise less deep renovation when compared to a scenario with regulatory measures (REG scenario) - thus, investments and related local employment is higher for the REG-scenario. A mixed approach (MIX scenario) which includes "a carbon price of EUR 44/tCO_2, incentives for renewables in H&C, support for heat pumps and renovation policies" results in investments between the two and incentivises deep renovation and fuel switch. In this context, the Commission highlights in its communication that an adequate policy mix also has to "avoid negative impacts on vulnerable consumers, […and...] target the renovation of their houses and keep the impact on their heating and electricity bills in check" (European Commission 2020a, p. 5). Reaching the renovation rates in the MIX scenario, however, means that barriers to cost-effective renovations are addressed (European Commission 2020b, p. 66). This particularly refers to access to finance and the split incentive (or landlord-tenant dilemma) and is most relevant for Member States in Central and South-Eastern Europe where there is lack of an appropriate policy framework to trigger cost-effective renovations (see e.g. BPIE et al. forthcoming; Agora Energiewende 2020a).

This means that the proposal of including buildings into the ETS does not make other policy measures redundant or unnecessary. It rather reflects that a carbon price is urgently needed to increase the economic viability of fuel switch (see e.g. IRENA et al. 2018), regulatory measures are needed to trigger deep renovation and other measures have to address in particular those barriers that cannot be solved with higher energy prices such as access to finance, split incentive, knowledge gaps and limited availability of local craftsmen as well as the protection of vulnerable consumers. This is in line with findings of other studies such as BPIE (2020) showing the multifold challenges in building renovation as well as Sebi et al. (2018) highlighting the need of new or strengthened policy measures besides carbon pricing.

Industry

The EU industry has managed to reduce its emissions with about 20% since 2005. However, emission levels have stabilized in the last decade, as the lowest hanging fruit has been exhausted and continued efficiency improvements are offset by production increases. Although further process optimization remains important, achieving deep reductions in this sector will require more profound changes, from a more circular production-consumption model to the roll-out of new, low-emission production technologies (including the use of carbon capture technology). Although many of those technologies already exist, most of them are currently still in R&D or demonstration phase. This – in combination with typically long investment cycles – poses a particular challenge for the climate transition in the industrial sector. It is therefore vital that necessary actions are taken in the coming decade to set the EU industry on a pathway towards climate neutrality by 2050.

Our CTI scenarios have identified four main levers to reduce emissions in the industry: 1) reducing the demand for emission-intensive industrial products via a transition to a circular and functional economy, 2) the large scale roll-out of new, low-emission technologies, including carbon capture, to some extent, 3) continued ambitious energy efficiency improvements and 4) switches towards climate-neutral energy vectors, including via electrification.

THE IA CONCENTRATES ON EFFICIENCY IMPROVEMENT WHICH CAN BE COMPLEMENTED BY LEVERAGING THE TRANSFORMATIVE POTENTIAL OF A FULLY CIRCULAR ECONOMY

Although the Commission's scenarios apply similar levers to achieve deep reductions on the longer term (2050), they clearly differ in terms of timing. Whereas the CTI scenarios leverage all four levers already in the coming decade, **the Commission's scenarios consider the potential for reductions by 2030 mainly limited to energy efficiency improvements** (in particular waste heat recovery in the textile, food & beverages, chemical and refinery sector), complemented with some limited fuel switches (a small degree of electrification and some replacement of natural gas by bio-methane). The Commission considers that the large-scale roll-out of new technologies and large-scale fuel switches will only be feasible as of 2035-2040, given the need for further technological developments and infrastructure needs. Finally, the IA acknowledges that the transition to a circular economy can serve as an enabler to achieve emission reductions across sectors, including in industry. However, it states that at this moment further research is needed on their quantification before this can be integrated in the modelling framework underpinning the scenarios. There is no data available on the assumed industrial production levels in the Commission's scenarios.

Whereas the ambitions in term of energy efficiency are comparable between the CTI scenarios and the Commission's scenarios, the lower use of the other levers leads to a lower overall GHG emission reduction in the Commission's scenarios (-23% to -26% between 2015-2030) compared to our CTI scenarios (-30% to -32%). These emissions are mainly driven by a lower overall final energy consumption (-14.7% to -16.8% by 2030 between 2015 and 2030) and to a lesser extent by fuel switches and electrification).

Agriculture, land use and bioenergy

The IA clearly recognizes the need to reduce non-CO_2 emissions from agriculture and the importance of preserving and developing the natural carbon sinks in soil and biomass. The agricultural sector represented indeed a significant share of EU emissions in 2015 with ~460 $MtCO_{2e}$ or 12% of total GHG emissions (when including CO_2 emissions from energy consumption in this sector). Natural sinks formed through land use, land-use change and forestry (LULUCF) on the other hand contributed to a reduction of 295 $MtCO_{2e}$, a capture of ~7% of the emissions for the same year. If properly managed, protected and restored, natural sinks can remove some remaining emissions in the future and will be essential to reach net-zero emissions by mid-century at the latest.

THE IA FOCUSES ON TECHNICAL MEASURES FOR LIVESTOCK AND CROP MANAGEMENT ALTHOUGH ACKNOWLEDGING THE CO-BENEFITS OF IMPROVING DIETS

For the non-CO_2 emissions from agriculture, the IA scenarios currently focus on technical measures while the CTI scenarios include lifestyles changes through shifting to healthier diets. The IA scenarios explicitly avoid any change in diets compared to the historical trend (i.e. about -5% meat consumption in 2030 compared to 2015), although the Commission recognises that such a change could lead to a reduction in GHG emissions as important as the potential reduction obtained with technical measures in the agricultural sector (up to ~30 $MtCO_{2e}$ annually by 2030). This confirms that combining technical and consumption-oriented measures would help significantly reducing agriculture emissions.

The IA technical measures settle to reduce the livestock emissions are (1) innovative animal breeding and growing practices, (2) farm-scale anaerobic digestion of manure with biogas recovery, and (3) the use of feed additives combined with changed feed management practices. To reduce non-CO_2 emissions linked to crop production, the IA suggest to (1) use nitrification inhibitors in large farms to decrease fugitive N2O emissions, and (2) adopt a more efficient use of fertilizers which could substantially reduce N2O emissions. All the technical measures combined allow to reduce agricultural non-CO_2 emissions by 30.6 $MtCO_{2e}$ (a decrease of about 7.7% compared to 2015 level).

In contrast, the CTI scenarios relied on a limited improvement of fertilizers use to increase the yields but also proposed substituting part of the meat by vegetal protein alternatives (between 11% and 28% of meat substitution, see Figure 6). Even though the CTI scenarios imply deep changes in the agriculture production, they are therefore better aligned with the WHO diet guidelines recommending halving the EU meat consumption. Leveraging diet changes not only reduces GHG emissions but also reduces the need (and costs) to deploy technical measures, improves health of Europeans, and frees land that can be converted into more efficient carbon sinks such as forests or permanent grasslands which in turn help restoring biodiversity.

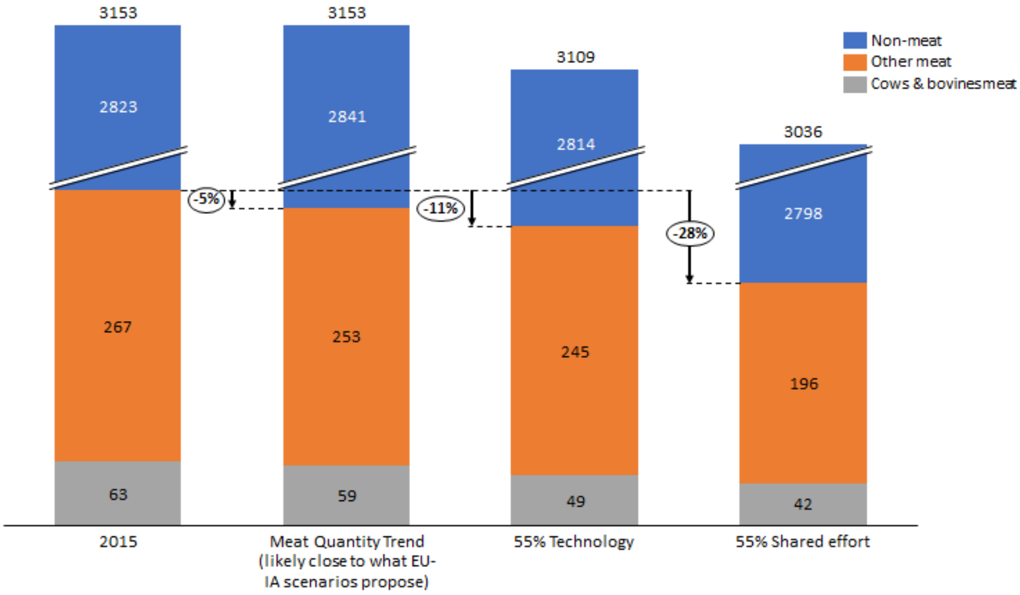

Figure 6: Food consumption, including 9% net export, in the 55% CTI scenarios compared to the historical meat consumption trend which likely reflects the IA scenarios (in kCal/capita/day).

THE IA PRESERVES THE CURRENT LULUCF SINK UNTIL 2030 WHILE THE CTI SCENARIOS INCREASE THE SINK THROUGH AFFORESTATION AND GRASSLANDS EXPANSION.

By 2050, about 500 Mt CO_{2e} will have to be annually removed from the atmosphere by LULUCF to offset residual emissions that are too difficult to abate in both the IA and CTI scenarios sets. However, the CTI scenarios reach around 500 Mt CO_2 already in 2030 thanks to a massive afforestation of the land freed up after changing diets, agriculture and land management practices.

In the IA scenarios, the LULUCF sink is maintained mainly by reducing deforestation, a limited afforestation (+2 m ha between 2020 and 2030) and improving soil and forest management. These practices could generate from ~44 to 80 $MtCO_{2e}$ of additional LULUCF sink by 2030 (and ~62 to ~123 $MtCO_{2e}$ by 2050). The IA mentions, though without including it in the scenarios, that protecting organic soils could reduce CO_2 emissions by about 50 additional $MtCO_{2e}$ by 2030 at a reasonable cost (Pérez Domínguez et al. 2020).

The CTI scenarios significantly increase the CO_2 absorption by LULUCF before 2030. In these scenarios, beyond stopping deforestation and preserving current forest, most of the sink increase comes from a massive afforestation of the land freed up thanks to the changes in agriculture production. The technical efficiency options exploited in the commission's scenarios are barely not used in the CTI scenarios. The forest sequestration is also improved in the CTI scenarios by lowering the harvest rates which may in turn reduce the availability of wood residues for bioenergy use. In contrast, in the IA, the increasing demand for solid bioenergy suggests an intensification of the harvesting practices.

THE DEMAND FOR LIQUID BIOFUELS ALMOST DOUBLES IN THE IA SCENARIOS COMPARED TO 2015 WHILE IT DECREASES BY ~15% IN THE CTI ONES

The total demand for bioenergy increases in the IA while it the increase is much more limited in the CTI scenarios. The IA suggests an increase of 8% to 10% by 2030 compared to 2015 (67% to 77% by 2050, see Figure 7). That increase comes from almost a doubling of the liquid biofuels demand by 2030 which is expected to play a key role in the transport sector, while the CTI managed to reduce it by ~15%. The demand for solid and gaseous bioenergy in the IA scenarios however remains comparable to 2015 (the increase staying below ~6% depending on the scenarios which falls between the two CTI scenarios).

CONSISTENCY IS NEEDED WITH OTHER LAND-RELATED CHALLENGES

The IA is not very explicit on the synergies, as well as potential trade-offs, between mitigation, biodiversity and adaptation needs. It acknowledges the need for adaptation activities as a means of maintaining forest sinks. However, the importance of agro-ecological practices to facilitate maintenance of sinks and yields on agricultural land, as well as to contribute to reversing biodiversity losses on agricultural land is not clearly addressed. For example, several droughts (including 2018) have already significantly affected yields. To achieve mitigation targets and avoid leakage, yield stability is important. This requires that soil health is maintained, soil degradation reversed, and agriculture can deal with increasing occurrence of pests and diseases, risks of droughts, soil erosion and other extreme events. Many agro-ecological measures simultaneously contribute to mitigation, biodiversity and adaptation needs; however it is not clear how these are considered in the IA assessment. Such measures would include for example diversified crop rotations, improved coverage of landscape features (including agroforestry), and organic farming practices. The focus in the agricultural component of the assessment is primarily, or exclusively, on technological solutions such as precision farming, nitrification inhibitors, feeding strategies, which have limited adaptation and biodiversity benefits. Moreover, this technological focus also risks leading to lock-in situations that can block the transition towards farming practices and production structures that fit with ecosystem boundaries and local environmental conditions, as well as ultimately result in climate friendly and more resilient farming systems.

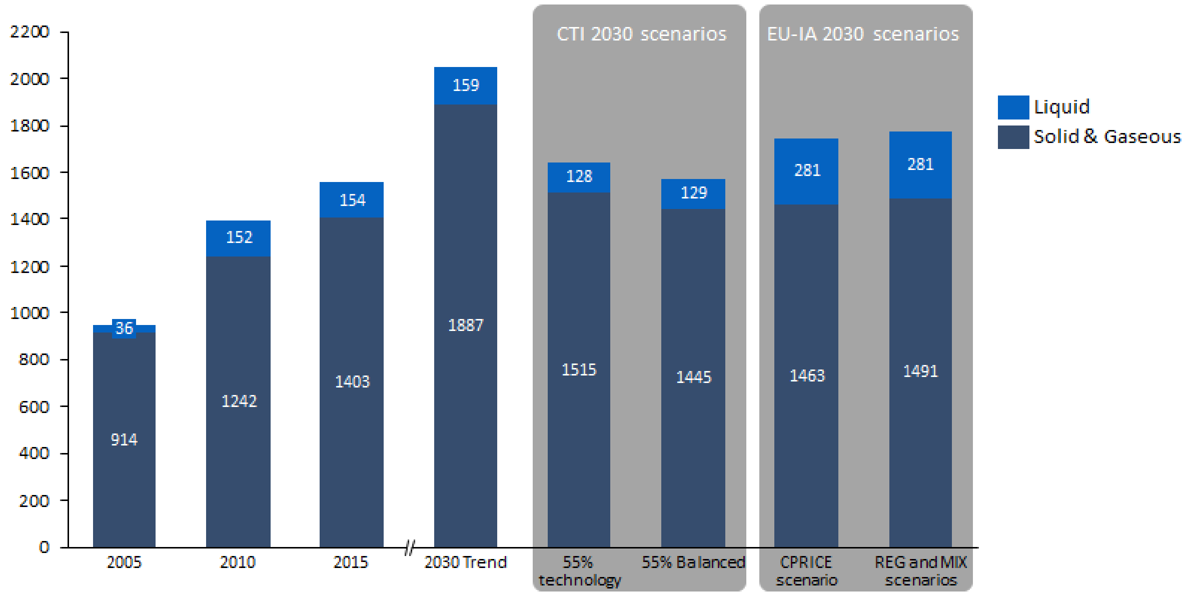

Figure 7: Bioenergy demand by type in CTI and IA scenarios compared to the historical trend projected until 2030

The Commission indicates contribution to Farm to Fork and Biodiversity Strategy via technological measures that improve nitrogen and phosphorous efficiency (and thus contribute to zero pollution ambition). It does not, however, explicitly consider the contribution to pesticide and biodiversity targets, including the targets to have 10% of agricultural area as high diversity landscape features and 25% of agricultural land organically farmed by 2030. It does refer to the role of the Common Agriculture Policy in funding mitigation technologies and changes in farming practices (non-CO_2), and it assumes that much of the additional incentives to invest in LULUCF sinks would derive from flexibilities linked to ESR and/or ETS. How these flexibilities are set up and managed will affect the credibility of ambitions set out.

Since the IA does not consider improving lifestyle and diet changes to reduce non-CO_2 emissions in agriculture, it also does not exploit the knock-on effects and systematic solutions required to transition to a climate-friendly agricultural sector. Therefore, the IA also not clearly considers the need to develop an integrated food and agriculture policy to manage the complex interactions between production and consumption in the food system, including supporting transitions by farmers and foresters, which are required to achieve reductions along the whole food supply chain. This is in contrast to what has been called for increasingly in recent years from research and stakeholders (including e.g. IPES Food 2019 or Willet et al. 2019).

REFERENCES

Agora Energiewende (2020a): How to raise Europe's climate ambitions for 2030. Implementing a -55% target in EU policy architecture, Berlin: Agora Energiewende.

Agora Energiewende publication (2020b): The European Power Sector in 2019: Up-to-Date Analysis on the Electricity Transition, Berlin: Agora Energiewende.

Agora Energiewende (2019): European Energy Transition 2030: The Big Picture. Ten Priorities for the next European Commission to meet the EU's 2030 targets and accelerate towards 2050.

BPIE, CLIMACT, Creara and Ecologic Institute (forthcoming): Lessons learned to inform integrated approaches for the renovation and modernization of the built environment. Study commissioned by DG ENER.

CAN Europe and Sandbag (2019): Just transition or just talk?, Brussels: Climate Action Network Europe and Sandbag (now Ember).

CLIMACT (2020): Increasing the EU's 2030 emission reduction target. How to cut EU GHG emissions by 55% or 65% by 2030. Study commissioned by EFC, Brussels: CLIMACT.

CLIMACT and NewClimate Institute (2020): A radical transformation of mobility in Europe: Exploring the decarbonisation of the transport sector by 2040.

DLR (2018): Development of the car fleet in EU28+2 to achieve the Paris Agreement target to limit global warming to 1.5°C. Berlin: Deutsches Zentrum für Luft- und Raumfahrt.

Gas For Climate and Guidehouse (2020): 2020 Gas Decarbonisation Pathways study.

European Commission (2020a): Impact Assessment accompanying the Communication Stepping up Europe's 2030 climate ambition, Part 1/2, SWD(2020) 176 final.

European Commission (2020b): Impact Assessment accompanying the Communication Stepping up Europe's 2030 climate ambition, Part 2/2, SWD(2020) 176 final.

European Commission (2020c): Stepping up Europe's 2030 climate ambition. Investing in a climate-neutral future for the benefit of our people, COM(2020) 562 final.

European Commission (2018): A Clean Planet for all A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy, COM/2018/773 final.

Görlach, B. (2014): Emissions Trading in the Climate Policy Mix — Understanding and Managing Interactions with other Policy Instruments, Energy & Environment vol. 25: 3-4.

IPES FOOD (2019). Towards a Common Food Policy for the EU - The policy reform and realignment that is required to build sustainable food systems in Europe.

IRENA, IEA, REN21 (2018): Renewable Energy Policies in a Time of Transition.

Kay, S. et al. (2019): Agroforestry creates carbon sinks whilst enhancing the environment in agricultural landscapes in Europe, Land Use Policy, 83: 581 - 593.

Löschel, A., Veronika G., Barbara L., Staiß, F. (2020): Klimaschutz vorantreiben, Wohlstand stärken – Kommentierung zentraler Handlungs-felder der deutschen Energiewende im europäischen Kontext. Expertenkommission zum Monitoring-Prozess „Energie der Zukunft".

Matthes, F. (2020): Pricing carbon. An important instrument of ambitious climate policy, Brussels: Heinrich Böll Stiftung.

Pérez Domínguez I., et al. (2020): Economic assessment of GHG mitigation policy options for EU agriculture: A closer look at mitigation options and regional mitigation costs (EcAMPA 3), Luxembourg: Joint Research Centre, doi:10.2760/4668.

Sebi, C.; Nadel, S.; Schlomann, B., Steinbach, J. (2018): Policy strategies for achieving large long-term savings from retrofitting existing buildings. Energy Efficiency, 12:89-105.

Stenning (2020): Decarbonising European transport and heating fuels -Is the EU ETS the right tool? Study for ECF by Cambridge Econometrics.

Velten, E.K., Stoll, T.; Meinecke, L. (2019): Measures for the promotion of electric vehicles. Ecologic Institute, Berlin. Commissioned by Greenpeace e.V.

Willett W., Rockström J., Loken B et al. (2019): Food in the Anthropocene: the EAT– Lancet Commission on healthy diets from sustainable food systems. Lancet.

ANNEX: Detailed sectoral implications of the IA scenarios compared to the CTI scenarios

Table 1: Power sector

Policy area	Range for CTI 55% scenarios Technology-focused and Shared Effort	Range for IA scenarios reaching -55% (REG, MIX, CPRICE)
Electricity demand	Electricity demand increases by 15% vs 2020 in a more technology-focused scenario, while it decreases by 10% in a shared efforts scenario with a higher focus on demand-side measures.	Electricity demand increases in all scenarios from about ~2,900 TWh in 2015 to ~3,200 TWh in 2030, so by +11% (REG) to +13% (CPRICE) and grows further by 2050.
Coal and fossil fuels phase-out	Together all fossil fuels in decrease from 42% in 2015 to 6% in 2030. Coal is almost fully phased out by 2030, going from 470 in 2019 to ~50 TWh in 2030 (~10% of 2019).	The share of fossil fuels decreases from 42% in 2015 to 17-18% in 2030. Figures for coal-based electricity generation are missing, but final energy demand for coal sinks to 9-11 Mtoe or ~115 TWh. Assuming most of it goes to power production this leads to ~50 TWh which is similar to CTI results.
RES support	RES production covers 75% of power production by 2030, on a stable or increasing power demand. This means RES has an 8.5% to 12% growth year-on-year, adding 90 to 130TWh of production per year in the next 10 years compared to ~40 TWh from 2010 to 2018. Biomass-based production stays roughly stable with 186 TWh in 2030. The RES share increases to 92% by 2050.	RES production covers 67% to 68% in the three scenarios of the power production by 2030 (so about 2200 TWh of the 3273 TWh).
Nuclear	Nuclear slowly phases out, contributing 17 to 20% of the production mix in 2030 (574 TWh).	Driven by MS policies, nuclear electricity generation falls by 2030 in both absolute and relative terms compared to 2015 to 466 (REG) to 493 TWh (CPRICE) which is below the CTI results.
CCS	No Carbon Capture and Storage (CCS) is assumed in power.	No significant deployment of CCS for power generation is projected in any of the considered scenarios by 2030.
Zero-carbon flexibility options	Variable renewable energy source production reaches 55 to 59% by 2030 and 74 to 80% by 2050. This is capped by the available network flexibility. Hydrogen-based production slowly starts in 2030, covering ~5-6% of production in 2050. In the shared-efforts scenario, 100% of the demand-side management potential is captured from 2030 onwards. Several zero-carbon flexibility options cover the daily and weekly flexibility needs (storage, inter-connections, biomass-firing). Seasonal flexibility is answered by zero-carbon dispatchable generation.	Variable renewable energy source production reaches 48% by 2030. The increasingly volatile nature of the electricity generation sources will require deployment of storage solutions through pumped hydro and batteries. Some hydrogen and power-to-gas are put in place, but they mostly rise after 2030 which is also assumed in the CTI scenarios.

Table 2: Transport

Lever	Range for CTI 55% scenarios Technology-focused and Shared Effort	Range for IA scenarios reaching -55% (REG, MIX, CPRICE)
Transport demand	Average transport demand per person across Europe increases by 7% by 2030 and is stabilized in the Shared effort scenario.	Passenger transport activity shows sustained growth relative to 2015 in all scenarios (18-20% by 2030)
Modal shift	The use of cars in passenger transport decreases from 80% of passenger kilometres (km) in 2015 to 73%-70% in 2030.	Car modal share in inland transport increases from around 80% in 2015 to 81-82% depending on the scenario. There is a significant shift towards rail, particularly in the REG scenario.
Utilisation rate and occupancy	The passenger distance per car and occupancy remain at their 2015 level in 2030, respectively 12,000 km/year, 1.62 passenger km/vehicle km in the technology focused. IN the Shared effort scenario, the passenger distance per car increases ~50% to 18,000 km/year in 2030. The occupancy increases to 2.1 passenger.km/ vehicle.km in 2030.	Mentioned but not quantified.
Technology share	In 2030, the car stock is composed by 12%-30% ZEV, and 9% to 11% of remaining vehicles are low emission vehicles (PHEV mostly).	By 2030, between 12% (CPRICE) and 14% (REG) of the car stock is composed of ZEV. LEV represent from 12% to 14% of remaining cars in the fleet.
Freight transport demand	The increasing trend in freight transport is partly counter-balanced with the ambition on the circular economy: both effects lead to freight volumes increasing by 7% to 20% up to 2030.	The increase in inland freight transport is around 30-33% by 2030 compared to 2015.
Modal shift	The truck use decreases from 50% in 2015 to 45% in 2030.	The truck modal share decreases up to 48% by 2030 (REG), with modal shifty mainly to rail.
Technology share	34% to 91% of new trucks are ZEV by 2030.	0.5-1% of the truck stock are ZEV and 8-9% are LEV.
Fuel mix	The combined demand for bioenergy for transport (including international bunkers) reaches 128 TWh in 2030 and 128 TWh to 180 TWh in 2050.	The combined demand for bioenergy for transport (including international bunkers lies between 230 and 290 TWh in 2030 and increases to a range between 560 and 690 TWh by 2050.

Table 3: Residential Buildings

Policy area	Range for CTI 55% scenarios Technology-focused and Shared Effort	Range for IA scenarios reaching -55% (REG, MIX, CPRICE)
Demand for heated areas	The yearly evolution is decreased down to +0.35% to -0.18%/year by 2030 leading to an average floor area per person of 40.8-41.5m²/person	No reductions of current trends in demand are applied
Envelope and heating efficiency	Energy renovation boosted to 1.8% to 2.4%/year by 2025 with an average of 35% of Energy Efficiency in both cases. By 2030, renovation rate reaches 2.3% to 3.4%/year with 80% of energy savings.	REG and MIX assumes more than doubling the rate of renovation. From 1% to 2.4% per year for 2026-2030. CPRICE results in 1.4%/year renovation rate. On average (2026-2030), energy savings range between 53% (for CPRICE) and 66% (for REG).
Heat decarbonisation	The consumption of electricity slightly increases in Shared Efforts in relative terms (from 22% to 25%) but decreases in absolute terms (33 TWh less, reaching 607 TWh in 2030) The share of fossil fuels used to heat existing buildings is reduced by 20% leading to a contribution of 47% by 2030 (mix of Oil (15-20%) and Gas (80-85%). Heat is fully decarbonised by 2050.	The share of electricity increase from almost 25% today to ~38% in all policy scenarios in 2030 and this share will be around 45% in all scenarios by 2050. Natural Gas cover ~30% of needs in 2030, Coal is fully phased-out in 2030 and almost no more Oil is consumed by then.
Appliances & consumer goods	Demand for electricity-dependant services reduces by 0.4%/year in Shared Efforts and increases by 1.8% in Technology, reaching a demand ranging from -5.6% to +16% in 2030 vs 2015. Energy efficiency is improved by 36% by 2030.	Not mentioned in the IA.

Table 4: Non-residential buildings

Policy area	Range for CTI 55% scenarios Technology-focused and Shared Effort	Range for IA scenarios reaching -55% (REG, MIX, CPRICE)
Demand for heated areas	The yearly evolution (m²/person) is decreased down to 0.4 to 0.5%/year by 2030.	No reductions of current trends in demand are applied
Envelope and heating efficiency	Energy renovation is boosted such that it reaches by 2025 1.9%/year with an average 73% EE, and by 2030 2.5% renovation rate with an average 82% energy saving.	Renovation rate increase ranges from 1.1% (in MIX) to 1.5% on average in 2026-2030 period.

Table 5: Industry

Levers	Range for CTI 55% scenarios Technology-focused and Shared Effort	Range for IA scenarios reaching -55% (REG, MIX, CPRICE)
PRODUCT DESIGN:		
Material switch	A major material switch is undertaken: in road vehicles, 16% of steel is replaced by carbon fibres, 16% by aluminium. In buildings, 17% of cement is replaced by plastics, 16% of cement by timber and 41% of steel by timber.	No info available on production levels and/or impact of material intensity/material switch/recycling rates
Material intensity of products	The improved design and the use of more efficient materials enables reducing the material use per product by 10% in steel, 20% in high value chemicals (HVC), 10% in cement, and 8% in other industries.	
Share of recycled materials	The share of recycled materials in new products increases to 65% for steel, 14% for high value chemicals (HVC), 75% for cement, and 50% for the other industries (excluding manufacturing waste recycling).	
PROCESS:	**Maximum ambition is required for all modelled action lever**	The bulk of the reductions come from **energy efficiency improvements**:
New process technologies	New technologies are deployed: 23 to 27% of primary steel is manufactured through HIsarna, 17 to 18% of primary cement is manufactured through polymers. Wet clinker is entirely substituted with dry clinker.	No large-scale use of new, innovative technologies before 2035-2040.
Energy efficiency	Within existing technologies, energy efficiency is improved by 26 to 28% to produce clinker, 17 to 18% for chemicals production (average for all chemicals modelled) and 9% for steel BOF process.	15 to 17% lower final energy consumption compared to 2015, mainly due to efficiency gains (waste heat recovery) in textile, food & beverages, chemicals and refineries, based on waste heat recovery.
Electrification	Processes are further electrified, assuming a major use of resistive heating. 50-70% of fossil fuels are substituted by electrification in steel, chemicals and other smaller industries.	No large-scale electrification, only a small shift from natural gas to electricity as an energy carrier (which is largely offset by efficiency improvements, leading to a very limited increase in electricity consumption).
Fuel switch	Fuel switches are important. First, 27 - 28% of the remaining coal and oil are replaced by gas in HVC and by hydrogen in traditional steel (Blast oxygene furnace - BOF). 51 - 60% is replaced by hydrogen in ammonia production and 24 - 30% in other chemicals manufacturing. Third, remaining fossil fuels are substituted at 15% by biomass in oxygen steel, 24 to 30% in chemicals (HVC, ammonia), 84 to 100% in cement, and 65 to 80% in other materials.	No large-scale fuel switching, only a limited switch to biofuels (bio-methane replacing natural gas)
CCS	7 to 24 Mt CO_2 are capture in 2030 to support several sectors (steels, HVC, ammonia, cement and others),	No 'significant' use of carbon capture before 2040.

Table 6: Agriculture and land use

Lever	Range for CTI 55% scenarios Technology-focused and Shared Effort	Range for IA scenarios reaching -55% (REG, MIX, CPRICE)
BEHAVIOUR:		
Change in diets	Calories consumed decrease from -1% to -4% (2030 vs 2015). Meat consumed per person is reduced by -11% to -28% while dairy consumption and production is stabilised at 2015 level. Share of ruminant meat down to ~19% of consumed meat (vs. 20% in 2015).	The diet level is following the current trend without further attempt to reduce total calories or meat consumption.
AGRICULTURAL PRACTICES:		
Reduce food waste	Maximum potential of waste collection is achieved: ~20% on-farm food crops waste and 50% of post-farm meat waste are collected (vs 10% on-farm and 40% meat post-farm in 2015).	IA scenarios activate technical measures based on carbon prices without giving data on deployment, e. g feed additives +changed feed management to reduce methane; more efficient fertiliser use to cut N_2O emissions.
Crop yields	Crop yields go up ~13% to 17% while minimising nitrous fertiliser use.	
LAND USE:		
Slow down land degradation	Maximum effort is made to stop land degradation.	IA scenarios leverage practices limiting deforestation, improving soil carbon sequestration and sustainable forest management to adapt forests so that they are a resilient natural carbon sink.
Land multi-use	17% less land is required to produce food thanks to multi-cropping and other changes in agriculture practices (2030 versus 2015).	
Surplus land	78% of all surplus land is afforested; 22% is dedicated to grasslands.	Not mentioned.
Forestry intensity	Forest harvesting intensity is lowered by ~12% (2030 vs. 2015) corresponding either to an average intensity reduction or the set-aside of 12% of EU forests. 2030 demand for sustainable bioenergy is met.	The demand for bioenergy plays an important role in increasing biomass production. As woody biomass increases, harvesting intensity is likely not modified or even increased.
Dedicated bioenergy crops	Less than 3 m ha-dedicated biofuel/energy crops are necessary; this is about a third of 2015 dedicated crops. In 2030, dedicated bioenergy crops represent about 40 TWh (between 2-3% of the total feedstock).	IA scenarios shift from conventional to much larger volumes of advanced biofuels from dedicated bioenergy crops and agricultural residues. In 2030, dedicated bioenergy crops supply 240 - 260 TWh (~12% of total feedstock).
BIOENERGY:		
Total demand	Total bioenergy demand increases from +1%- +5% compared to 2015.	Increase from +8% - +10% in 2030 and from +67% to +77% (2050 vs. 2015).
Liquid biofuel demand	Decrease from -16% to -17% compared to 2015	Important increase (~+78%) but it does not represent more than 20% of the total use of biomass in any of the scenario (compared to 2015).