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Setting an ambitious EU climate target for the year 2040

Recommendations by the German Environment Agency

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Setting an ambitious EU climate target for the year 2040

Recommendations by the German Environment Agency

by

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German Environment Agency

On behalf of the German Environment Agency

Executive Summary

The European Climate Law (ECL) mandates the European Commission to propose an emission reduction target for 2040 within six months following the first global stocktake referred to in the Paris Agreement, i.e. by May 2024.

The ECL obliges the European Commission to take into account the latest and best scientific findings and to take the recommendations by the European Scientific Advisory Board on Climate Change (Advisory Board) as a point of reference for setting the 2040 climate target. This recommendation was published in the Advisory Board's comprehensive report, published in June 2023, and advises **a net greenhouse gas (GHG) emissions reduction by 90-95% for the EU by 2040, relative to 1990,** corresponding to a 2030-2050 budget of 11-14 Gt CO_{2eq}. The report provides extensive reasoning and scientific evidence how this target range was derived.

The German Environment Agency (UBA) welcomes the timely publication of this report and urges the European Commission and European policy makers **to follow scientific advice, aim for the most plausible climate ambition and set an intermediate domestic 2040 net GHG emission reduction target of 95%, compared to 1990.**

However, a discussion that focuses only on the final figure of the 2040 target would not adequately address the intricate nature of GHG reductions and the essential prerequisites for successfully achieving the target. Therefore, the proposal for the 2040 climate target needs to be supplemented with additional information by the European Commission, allowing politics and stakeholders to evaluate the ambition of different target options, to provide clear guidance on the architecture of the target, in particular regarding the relation of emission reductions and carbon sinks, and to address the burden sharing between sectors and member states. Moreover the 2040 target should not be understood as a single-year target only, but rather as a process of continuous ratcheting up of climate ambition with regular reviews and updates.

The UBA therefore strongly recommends the European Commission to consider the following key aspects:

1. Evaluate the ambition of the target, including the cumulative emissions up to 2040

- Aim for an ambitious 2040 net GHG emission reduction target of about 95%, taking into account the recommendation of the UBA and the European Scientific Advisory Board on Climate Change (Advisory Board)
- Provide transparency on the assumptions taken for estimating the remaining global CO_2 budget and the associated uncertainties
- Provide transparency on the remaining global CO_2 budget share that the EU intends to consume
- Evaluate the ambition of EU's climate target with regard to the global CO_2 budget

2. Sinks are needed to compensate for residual emissions and to achieve net negative emissions

- Focus on reducing GHG emissions and keep emission reduction targets separate from negative emission targets
- Separate targets for natural sinks and technical sinks
- Develop a sustainable and robust carbon sinks strategy

- Implement a clear and reliable monitoring, reporting and verification system (MRV) for sinks
- Develop a clear and robust governance structure for regulating carbon storage

3. Strengthen EU-wide emissions trading while also leveraging national responsibility for achieving climate targets

- Assess the implications of different approaches for the integration of EU ETS 1 and 2
- Ensure a high degree of Member States' responsibility for achieving emission reduction targets while strengthening the EU level
- Assess the potential benefit of (indicative) sectoral targets

4. Understand the 2040 target as a process, not a single year target

- Frame and communicate the 2040 target as process that starts now and establish a regular review mechanism
- Install a stocktaking and review process for the 2040 target mid of the next decade

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1 Introduction

The European Commission has set itself ambitious goals to combat climate change and achieve a sustainable future. Building upon the EU long-term strategy "A clean planet for all" the EU presented the EU Green Deal in 2019, encompassing a series of policy initiatives aimed at achieving net-zero greenhouse gas (GHG) emissions by 2050 and transforming the European economy in a just and sustainable manner.

To support the climate ambitions outlined in the EU Green Deal, the European Commission introduced the Fit for 55 package in July 2021. This legislative package has proposed a revision of existing EU laws to effectively reduce GHG emissions, but included also a set of new legislative initiatives. The Fit for 55 package includes a range of measures and strategies targeting basically all sectors. The package will set the EU on track to reach its current climate target for 2030 of reducing net GHG emissions by at least 55% compared to 1990 levels.

Currently, the EU has yet to fully implement the ambitious Fit for 55 climate policy package - of which most parts have come into force in spring 2023 - via a wide set of delegated and implementing acts. Nevertheless, the focus shifts now to the coming decade until 2040 and how to set the enabling conditions for reaching the EU net-zero emissions target in 2050 and become the first GHG emission neutral continent.

The central EU legislation for this task is the European Climate Law (ECL, Regulation (EU) 2021/1119), adopted in 2021. The ECL not only enshrines the net-zero emission goal into law, but also sets a legally binding target for 2030 and mandates the European Commission to propose a 2040 emission reduction target within six months following the first global stocktake referred to in the Paris Agreement, i.e. by May 2024.

With regard to the 2040 climate target, the ECL obliges the European Commission to take into account the latest scientific findings and to take the recommendations by the European Scientific Advisory Board on Climate Change (Advisory Board) as a point of reference. The comprehensive report published by the Advisory Board in June 2023 recommends to reduce domestic net emissions in the EU by 90-95% by 2040, relative to 1990 and keeping the cumulative emissions between 2030 and 2050 below 11-14 Gt CO_{2eq} (Advisory Board 2023a). The report provides extensive reasoning and scientific evidence on how this target range was derived.

The German Environment Agency (UBA) welcomes the timely publication of this report and supports an ambitious emission reduction target. The UBA, therefore, urges the European Commission and European policy makers to follow scientific advice and aim for an ambitious, realistic and domestic target.

The aim of this paper is to complement the discussion with considerations and suggestions on the overarching climate target and the underlying architecture, especially with a view to the relation of emissions and sinks, and on broadening the perspective with a multi-year perspective in contrast to a single-year focus.

2 Evaluate the ambition of the target considering the cumulative emissions up to 2040

It is widely acknowledged that there is a direct link between the cumulative CO_2 emission concentration in the atmosphere and global warming (IPCC 2021, Fig. SPM. 10). In its 5th assessment report (IPCC 2014) the Intergovernmental Panel on Climate Change (IPCC) most prominently followed the approach of calculating a "remaining CO_2 budget"[1] that allows - with a certain probability - to stay below a certain temperature limit, e.g. 1.5 degree in line with the Paris Agreement (PA). Hence, the concept of a budget can help to evaluate the ambition of a mitigation target (in 2040). Nonetheless, there is no direct physical link between the temperature limit of the Paris Agreement and a greenhouse gas budget for the EU. The ECL's requirement to specify the "total volume of net greenhouse gas emissions that are expected to be emitted in that period without putting at risk the Union's commitments under the Paris Agreement" (Regulation (EU) 2021/1119), therefore indicates assumptions that should be made transparent.

New and improved CO_2 calculations were presented in the IPCC AR6 report. The updated figures published by the IPCC in June 2023 show that the remaining carbon budget is declining very fast and could be depleted in a couple of years already (Forster et al. 2023). Despite methodological refinements and improvements, the calculations are subject to uncertainties, e.g. about the relationship between cumulative emissions and climate response, the historical and current emission levels, the development of negative emissions, the level and climate impact of non-CO_2 emissions and socio-technical changes (IPCC 2021, Table SPM. 2).

However, a fair distribution of a global CO_2 budget is a highly contested issue, as it is in essence a normative question of fairness and justice. Even though there are several different distribution approaches, e.g. the grandfathering approach (i.e. based on current emission shares), the per-capita approach, a cost-optimal distribution or approaches that account for historical responsibility and mitigation capacities, not all of classify as fair (Rajamani et al. 2021). Furthermore, these approaches often benefit some states, while disfavouring others (Advisory Board 2023a, Table 2).

Instead of a top-down approach of distributing the CO_2 budget, parties under the Paris Agreement opted for voluntary emission reduction "pledges", so called NDCs. However, all NDCs combined still fall clearly short of staying within a global necessary reduction, that would limit global temperature increase to well below 2°C or 1.5°C as was agreed in the Paris Agreement, and some do not address the question of fairness and justice sufficiently. In the case of the EU, the fairness dimension is insufficiently addressed under the current climate legislation and also the ECL leaves open whether the expression 'without putting at risk the EU's commitments under the Paris Agreement' refers to the EU alone or the combined NDC's. It is consequently imperative for the EU to agree on further emission reduction goals to remain within the PA and ensure the success of the international climate policy.

For the EU, GHG budgeting is already an integral part of its climate change policies. It should be noted here that this version of budgeting does not follow the same reasoning as the physical determination of a global CO_2 budget. The EU assigns annual sectoral GHG budgets to the EU ETS 1 and 2 and to the sectors covered by the Effort Sharing Regulation (ESR). Translating EU's GHG climate targets for 2030, 2040 and 2050 into annual budgets for these sectors therefore allows to calculate an indicative emissions budget of the EU. In addition to this, the European

[1] In the IPCC reports the term "carbon budget" is used. This Scientific Opinion Paper uses the term "CO_2 budget" in order to point towards the difference to a "greenhouse gas budget".

Commission is mandated by the EU Climate Law, to publish "the projected indicative Union GHG budget for the 2030-2050 period" (Regulation (EU) 2021/1119, Art. 4 (4)). This assessment report needs to include the "most up-to-date scientific, technical and socioeconomic findings" and incorporate the work of independent and official experts, such as the Advisory Board (Regulation (EU) 2021/1119). Consequently, the Advisory Board report, see Chapter 3, recommends to keep cumulative emissions between 2030 and 2050 below 11-14 Gt CO_{2eq} (Advisory Board 2023a).

The calculation uncertainties and distribution difficulties aside, the CO_2 and GHG budget is nevertheless an important communications tool, since it puts the urgency of climate action in concrete figures. The German Constitutional Court decided in 2021 that emission reduction policies must take into account the residual CO_2 budget as it was calculated by the German Advisory Council on the Environment (BVerfG 2021). Furthermore, some actors, such as the Climate Action Tracker, use it to check the ambition levels of national mitigation pathways.

The UBA recognizes the importance of providing clear and transparent information on the GHG budget calculations underlying EU's climate policy and suggests to consider the following aspects:

- **Provide transparency on the assumptions made for estimating the remaining global CO2-budget and the associated uncertainties**

UBA fully supports the Advisory Board's view advocating for "making transparent choices about the factors that influence the carbon budget's size and reflect physical and socio-economic uncertainties" (Advisory Board 2023b, p. 11). This relates to the temperature goal itself, the probability with which it might be achieved and the assumptions on the development and contribution of non-CO_2-emissions to global warming.

- **Provide transparency on the remaining global CO2 budget share that the EU intends to consume**

The EU should provide transparency on the share of the remaining global CO_2 budget the EU intends to consume. This can be done by calculating an indicative GHG budget – i.e. the projected cumulative emissions of the EU - in the 2030-2050 period (plus the GHG budget the EU will likely consume in the 2020-2030 period) and showing the share of CO_2 emissions in this indicative GHG budget. Whether this share in the global CO_2-budget claimed by the EU can be regarded as "adequate" or "fair" will probably be subject to controversial discussions. But the transparency enhances the credibility of EU's climate policy.

- **Evaluate the ambition of EU's climate target with regard to the global CO2 budget**

Calculating the EU's indicative share in the remaining global CO_2 budget thus helps to evaluate the ambition of current and future climate targets by comparing this share with a range of possible equity-fair shares and to identify ambition gaps. This is especially due to the fact, that emission reduction pathways showcase how a certain budget can be complied with, e.g. through stricter reduction efforts in the near future and in the beginning of a period and more moderate ones later on. As there will probably be a gap between the 2020-2050 GHG budget calculated by the most ambitious GHG emission reduction pathway and the range of GHG budgets calculated by assuming different equity-fair shares (Advisory Board 2023a, Table 11), the European Commission needs to address this gap and should outline options how to bridge this gap.

3 Discussion on a possible target range for a 2040 climate goal

In order to conform with the Paris Agreement, and its own climate agenda, but also to provide clarity and predictability for the industry and the general public, the EU Climate Law tasks the European Commission with establishing a new, intermediate 2040 GHG reduction goal on the pathway to climate neutrality by 2050. This climate target has to be drafted within six months of the second global stocktake, i.e. mid-2024, and has to utilize the "best available and most recent scientific evidence" (Regulation (EU) 2021/1119, Art. 4).

Considering the faster-than-expected decline in the residual carbon budget and the increase of global average temperature, noted by the IPCC in its recent update of headline indicators (Forster et al. 2023), UBA is of the opinion that the EU should aim at the maximum plausible ambition in setting this target. In the following, we aim to derive an ambitious and realistic target (range) that is in line with Europe's responsibility to the international commitments. Our conclusions are based on existing scientific information and publications, in-depth modelling was not conducted. We would like to emphasize that any climate target should be defined domestically. Cooperative approaches should only be used to contribute to additional climate ambition abroad, not to ease the achievement of EU's climate targets (UBA 2018).

The current EU 2030 and 2050 GHG reduction targets are defined as net-emission reductions targets, i.e. emissions and carbon sinks ("negative" emissions or carbon removals) are added up. Thus, the 2030 target of reducing emissions by net 55% compared to 1990 can be translated to around minus 53% emission reductions, excluding LULUCF (European Commission 2020, Table 26). For 2050, the EU has set itself the goal to reach net zero emissions, which would translate into emission reductions compared to 1990 in the range of around 92% to 95%, excluding LULUCF (Climate Action Tracker 2023).

Aside of tasking the European Commission to establish an intermediate 2040 climate target, the EU climate law also established the Advisory Board, supporting the European Commission with sound scientific advice and expertise. In this function, the Advisory Board released a detailed scientific review in June 2023, proposing an ambitious minus 90 to minus 95% net GHG reduction target for the EU by 2040, compared to 1990 (Advisory Board 2023a). Compared to the EU base year emissions in 1990, this translates to a reduction of gross emissions, i.e. excluding natural and technical sinks, between around 72% and 88%[2]. We support the analysis in general, as it reflects the urgency, but also the feasibility for Europe to achieve their 2050 target, become a leader in the fight against climate change and transform into the first climate neutral continent, as the stated in the EU Green Deal. The dedication shown by the Advisory Board emphasizes the importance of this goal and highlights the potential for positive impact on a global scale.

The scenarios assessed by the Advisory Board reveal common features in achieving decarbonization goals. These include widespread deployment of wind and solar energy, along with the electrification of energy use and the expansion of alternative fossil fuel sources like hydrogen. By implementing these key strategies, the EU power sector can nearly reduce carbon emissions by 2040 completely by phasing out coal-fired (fossil fuel) electricity generation by 2030 and unabated gas-fired generation by 2040. While minimizing reliance on CO_2 removal

[2] Gross GHG emissions in 2040 range between 697 Mt and 1,596 Mt CO_{2eq} according to the Advisory Board (2023a), figure 37. We compared this to the value of 5,635.72 Mt CO_{2eq} in the base year 1990 (UNFCCC 2023).

techniques, achieving climate neutrality still necessitates large-scale carbon removal measures - natural and technical (Advisory Board 2023a).

UBA fully supports the approach of prioritizing emission mitigation, i.e. substitution and avoidance of fossil fuels and emission intensive processes, as the first step. Only GHG emissions that cannot be eliminated through mitigation, so called residual emissions, have to be compensated by sinks to achieve net zero balance in 2050. It remains, nevertheless, unclear if all mitigation strategies are fully utilized and the European Commission needs to make sure that all possible decarbonization pathways are explored and applied.

Furthermore, the consideration of different levels of feasibility, on the one hand geophysical, technological and socio-cultural, and on the other hand with regards to environmental risks and technical challenges is very important from an environmental climate protection perspective.

UBA welcomes the Advisory Board's comprehensive study and supports an ambitious reduction target. It has to be stressed, however, that considering the precautionary principle, EU's historical emissions and its ambition to be a global leader in the fight against climate change, minus 90% net-GHG reduction should be the bare minimum and the European Commission should aim for the upper Advisory Board's recommendation of minus 95%.

Critical in this respect are, from our point of view, the resolute and accelerated emission mitigation strategies by substituting and avoiding fossil fuels and emission intensive processes, linked with a sustainable carbon sink strategy, which will be discussed in the following chapter. We therefore strongly recommend that the primary goal for 2040 should be to reduce gross emissions as much as possible and aim for the upper level of gross emission reductions as far as possible. The contribution of negative emissions, i.e. carbon sinks, is highly uncertain and should therefore play only a limited and complementary role on the path to 2040 (cf. chapter 4).

Based on our analysis, the UBA recommends a target of 95% net GHG reduction by 2040, compared to 1990 with a maximum of corresponding gross emission cuts.[3]

[3] Our figures are derived by using the IIASA AR6 scenario database. In our case the filtering and selection process mirrored the IPCC recommendations in terms of temperature and emission, i.e. limiting warming to 1.5°C with no or low overshoot, as well as the underlying necessity that only a minimal amount of CDR should be used and the prevalence of renewable energy deployment.

4 Sinks are needed to compensate for residual emissions and to achieve net negative emissions

Looking at the overarching goal to achieve climate neutrality in the EU by 2050, it is acknowledged, that emission reduction alone is not sufficient to reach net-zero GHG emissions. The residual emissions, i.e. emissions which cannot be avoided, have to be compensated by negative emissions, i.e. carbon sinks, from the atmosphere. Furthermore, from 2050 on, the EU needs to become not only climate neutral, but net-negative i.e. it must absorb and safely store more carbon from the atmosphere than it emits (Advisory Board 2023a). Additionally, with defining already the 2030 target as "net" target it is evident that carbon removals are a key element of the upcoming climate policy architecture.

Looking ahead to the 2040 and 2050 targets, it is necessary to:

- **Focus on reducing GHG emissions and keep emission reduction targets separate from negative emission targets**

In line with the precautionary principle, emission reductions by avoidance and substitution of fossil fuels and emission intensive processes have to be the primary approach to reach the 2030, 2040 and 2050 EU climate targets. Emissions can be avoided in the first place by applying the principles of sufficiency and efficiency, e.g. renovation, repairability, increased circular economy or replacing GHG intensive technologies and products with GHG neutral alternatives. In addition to an avoidance strategy, substitution, which involves replacing harmful fossil fuel energy sources with renewable energies, will also help to reduce the generation of GHG. However, and despite of ambitious emission reduction policies and measures, residual emissions, i.e. emissions that cannot be avoided, will remain. This, for example, is true in the agricultural, waste and some industrial sectors, e.g. the lime and cement production (Purr et al. 2019; Duscha, Wachsmuth, Eckstein & Pfluger 2019; Warszawski et al. 2021; Frauenhofer - ISI 2021). These emissions have to be counterbalanced by negative emissions via natural sinks, e.g. forests, rewetted peatlands or afforestation, and/or technical sinks, e.g. Direct Air Capture Storage (DACCS) or Bioenergy Carbon Capture Storage (BECCS). However, it has to be emphasised that negative emissions should not be used to offset other than unavoidable remaining emissions, as this would delay or water down emission reduction efforts, thus putting climate change mitigation at risk and cementing fossil fuel structures. Additionally, it has to be pointed out that, carbon sinks are not infinitely available and have limited capacity at the moment. The potential availability of natural sinks, for example forests, fluctuates over time, e.g. due to changes in the age structure of forests. Technical sinks, such as BECCS and DACCS, are currently limited as well, e.g. due to the restricted availability of sustainably produced biomass (BECCS) or the high demand for renewable energy (DACCS), and, at the same time, linked with environmental risks, high development and operational costs and long-term control and management requirements. Carbon sinks should therefore be used only to counterbalance currently unavoidable emissions and/or reduce the amount of CO_2 already emitted into the atmosphere. To account for the necessity of negative emissions and risks attached, regulatory consideration and prioritization is needed that follows the criteria of sustainability, nature conservation and risk minimization. Therefore, targets for negative emissions should be kept separate from emission reduction targets (Voß-Stemping, Schultz & Purr 2022; Purr & Spindler 2023). Similar to the 2030 target, there should be a clear limit on the amount of negative emissions that may be accounted towards the 2040 climate target in the ECL.

► Separate targets for natural sinks and technical sinks

As stated above, carbon sinks will be necessary to reach net-zero emission in 2050 and net negative emissions afterwards. In that case, natural carbon sinks, i.e. ecosystems such as soils and forests, should be considered first as they do not require large and expensive infrastructures and have many ecological co-benefits, such as wildlife and biodiversity conservation, the improvement of the near-ground microclimate, the enhancement of the water balance and the provision of other ecosystem services (IPCC 2023; Voß-Stemping, Schultz & Purr 2022). In this way, it creates synergies helping to counteract other environmental challenges, e.g. biodiversity loss, and ties in with other EU environmental and sustainability policies. Consequently, the aim should be to preserve, safeguard and restore natural carbon sinks to compensate for unavoidable emissions, while ensuring undesired side effects, such as land use conflicts, are minimized. It has to be mentioned, however, that carbon stored in natural sinks can be reversed by natural disasters or mismanagement and climate change is putting forests, our largest natural sink, increasingly under pressure with draught, storms and other extreme climate events (Patacca, Marco, Lindner, Lucas-Borja et al. 2023; Böttcher et al. 2022; Geden & Schenuit 2020). In this respect, technical sinks are likely needed as well, but should be treated with caution. Their potential for positive and lasting climate impacts, especially with regard to permanent storage, possible leakage, and energy expenditure, has yet to be proven (von Goerne, Weinlich & May 2010; IPCC 2005; Purr & Spindler 2023). Furthermore, technological and social innovations must be developed and constantly advanced in order to reduce the technical and socially acceptable minimum of unavoidable emissions, continuously and according to the latest state of knowledge and research (Purr & Garvens 2021; Purr & Spindler 2023). Despite technological development potential, unavoidable emissions will remain in the long term. Nevertheless, there is the need for net-negative emissions in the second half of the century. With a very ambitious climate protection policy in all sectors, natural sinks, with their added synergetic advantages, can compensate for residual emissions and reduce the need for net-negative emissions after 2050. The earlier (gross) emissions are reduced and the more natural sinks contribute, the lower are the cumulative emissions and accordingly the lower is the need for technical sinks, i.e. this could, under ideal conditions, even be reduced to zero (IPCC 2022).

► Develop a sustainable and robust carbon sinks strategy

Emission reduction efforts are currently not keeping pace with the requirements to limit global warming to 1.5° (IPCC 2023). Thus, there is the need for a robust carbon sinks strategy that considers and balances environmental and climate impacts and evaluates the necessary measures to achieve sustainable negative emissions. The carbon sinks strategy needs to address the question in which form and to what extent natural and technical carbon sinks contribute to achieving the targeted GHG neutrality and a cross-sectoral negative GHG balance in a sustainable manner. Thus, the strategic vision for CCUS, that the European Commission has announced for mid-2023, should evaluate natural and technical sinks in an integrated manner. The strategy should also define which emissions from which applications are, according to the latest scientific knowledge, deemed to be unavoidable by mid-century, how many negative emissions are needed to offset these remaining emissions and how many negative emissions are needed in addition to reduce the amount of carbon in the atmosphere. Today, a common understanding of which emissions are truly unavoidable or which emissions are only difficult (or expensive) to abate is still missing[4]. So preliminary the strategy should also define which and how many emissions from which applications will be used for Carbon Capture and Storage. The availability,

[4] In our understanding, unavoidable, residual emissions come mainly from agriculture, some industry processes such as cement and lime production as well as waste and waste water treatment.

readiness, reliability and durability of technical sinks should be ensured. In addition to the present knowledge, further research and testing is needed to assess the environmental and climate impacts of technical sinks more precisely and in the long term, i.e. sustainability, leakage problems and energy consumption. To this, the UBA proposes research and testing of CCS in thermal waste treatment plants. (Purr & Spindler 2023).

- **Be very clear in communication and terminology**

An appropriate, goal-oriented and acceptance-creating communication is imperative for public and private actors to have a clear idea about the EU GHG reduction strategy. This ensures planning security, reliability and acceptance. Connected to this, the European Commission should use a precise and reliable terminology. It is therefore necessary to define which emissions from which application are considered unavoidable, how many negative emissions are needed to offset these remaining emissions, and how many additional negative emissions are needed to reduce the amount of carbon in the atmosphere.

- **Implement a clear and reliable monitoring, reporting and verification system (MRV)**

In order to address in-/sufficiency, non-permanence or reversibility, the main risks of natural and technical sinks and to guarantee a sustainable carbon sink management, the European Commission should create a transparent and robust system for monitoring, reporting and verifying (MRV). This should be linked to and be compatible with the existing EU ETS Monitoring and Reporting Regulation and the CCS Directive. The MRV-system has to ensure that emissions are safely and permanently stored and to provide clear rules for liability in case the carbon is released into the atmosphere at a later stage. With respect to natural sinks – the effect of measures to strengthen eco-systems have to better integrated in MRV-systems with a higher granularity to allow for better monitoring and adjustment of measures. With respect to technical sinks – MRV needs to cover the emissions along the entire process chain, i.e. from the capturing, over transporting to the storing process. Especially, the temporal long dimension of gaseous CO_2 storage in geological formation of several thousand years needs to be addressed in an MRV-system. Despite preliminary tests of accelerated carbonization, the normal carbonization period is currently several thousand years.

- **Develop a clear and robust governance structure for regulating carbon storage**

A clear separation of (gross) emission reductions and negative emissions leads to the question how this can be implemented in the climate policy architecture, especially within the two EU emissions trading systems (ETS 1 and 2) and under the Climate Action (Effort Sharing) Regulation (ESR). A clear set of binding rules complies with the EU treaties is needed on how many negative emissions can be used for offsetting against residual emissions and who (which sectors, which activities, which entities) should have access to such compensation opportunities. To ensure planning security for long-lasting investment and infrastructure decisions for carbon storage, these rules need to be developed and adopted at an early stage. It has to be made clear that (technical) carbon storage solutions can only be a small and residual element in the climate policy framework, when all other abatement solutions have been exhausted.

Under the existing EU ETS 1 emissions from large point sources (installations) can be mitigated from being released into the atmosphere by capturing CO_2 from combustion or industry processes and storing it permanently in appropriate geological sinks (CCS)[5]. Currently, the usage

[5] A clear definition of "Carbon Capture & Storage" (CCS) is necessary as the term is used deliberately and often does not clearly state what is meant and included. It has to be underlined, that CCS per se is not a negative emission technology, as it only prevents the

of CCS is not restricted, but open to all activities covered by EU ETS 1 and there are no limits regarding the volume of carbon stored. From an environmental point of view, it seems plausible to restrict the use of carbon storage to unavoidable emissions in order to avoid overinvestments in large (energy, area and material consuming) infrastructures that have not yet proven over centuries their environmental safety and their long-term effectiveness in storing carbon. Moreover, the limited (safe) carbon storage potentials will be needed in the future and the next generations to store carbon that has been removed from the atmosphere to achieve net-negative emissions, using BECCS and DACCS.

The question is whether these types of carbon removal and storage should be allowed into EU ETS, as proposed by Rickels et al. (2022). Links for carbon removal options with the EU ETS may also arise under the proposal for a Union-wide framework for the certification of carbon removals. With the aim to spur investments into carbon removal technologies, nature based and technological approaches, the European Commission proposed a union-wide voluntary carbon certification framework currently prepared for the EU trialogue process. The key component of the proposed regulation are EU certification quality criteria with the aim to ensure high-quality and sustainable carbon removals in Member States. A pending critical issue in the European Commission's proposal is the use of certificates which can range from using certificates as a basis to assess funding (e.g. under the Common Agricultural Policy - CAP) or in voluntary carbon markets to offset emissions (Erxleben, Voß-Stemping & Bretschneider 2022).

The ETS Directive obliges the European Commission to address in a report to be presented by July 2026 the question how and to what extent carbon removals should be integrated into the EU ETS (Directive (EU) 2023/959, Article 30 (5)). However, an unlimited, unrestricted linking of carbon removal and carbon storage technologies with the EU ETS could reduce the pressure to transform the economy thus putting climate change mitigation at risk (Edenhofer et al. 2021a). In this respect it is important to emphasize that any carbon removal certificates implemented in the EU ETS are intended to offset emissions, rather than achieve net-negative emissions, which will be necessary from 2050 onwards. Furthermore, very strict rules must be put in place to avoid double counting and ensure additionality of the removals. How the carbon market can be turned into an instrument to foster the development of net-negative technologies and infrastructure therefore remains to be answered. Moreover, the assumption that the removal of one tonne of carbon from the atmosphere is equivalent to the release of one tonne of carbon does not differentiate between permanent or non-permanent removals and therefore has to be critically discussed[6].

The European Commission should therefore assess whether it would be possible and in favour of the overarching climate goals to restrict the use of carbon storage in the EU ETS, regardless of whether the carbon is captured from point sources or from the air, to activities that cannot avoid their emissions by the beginning of the post-2040 decade[7], when the cap of EU ETS 1 becomes zero.

release of emissions in the atmosphere at the point source. If CO_2 is produced from sustainable biomass usage and captured through BECCS or directly extracted from the atmosphere, only then these CCS applications are classified as technical sinks.

[6] One tonne of avoided emissions does not equal one tonne of removed emissions. Neither nature nor technology-based approaches ensure sustainable and permanent storage. Nature based eventually release the carbon back to the atmosphere, whereas BECCS and DACCS come with scientific knowledge gaps, risks and potential adverse side effect of the geological storages' sites. Not to mention high costs for energy and infrastructure installations (further fuelling carbon-based economy) as well as adverse biodiversity including land degradation effects.

[7] By 2040, there will likely be residual emissions in the mineral products and chemical industry, in waste incineration, aviation and shipping.

5 Strengthen EU-wide emissions trading while also leveraging national responsibility for achieving climate targets

The current climate policy target architecture sets separate binding emission reductions targets for the sectors covered by the EU ETS (or more recently: ETS 1, approx. 40% of total EU GHG emissions), i.e. heavy industries, the energy sector, aviation and maritime activities, on the one side and all sectors not covered by the EU ETS 1 on the other side[8]. Those other sectors are covered by the Climate Action (Effort Sharing) Regulation (ESR) (approx. 60% of total EU GHG emissions) – in particular transport and heating. This architecture has been well established and proven to be generally functional so far – even if the reduction incentives in intergovernmental emissions trading under the ESR were weakened by excess emission quotas in the commitment period up to 2020. In addition, the EU has built up comprehensive reporting and monitoring structures for the LULUCF sector. In the ETS 1 sectors, there are no national and no sectoral targets at all, but emissions are reduced where it is cost efficient. Overall emissions are limited by the EU-wide cap. In contrast, for sectors not covered by the ETS 1, Member States are responsible for meeting their national targets, while some flexibilities are allowed. Overall emissions are limited by those binding national targets.

With the creation of a second ETS (ETS 2) for fuels under the Fit for 55 package covering the buildings, road transport and remaining industry sectors from 2027 onwards, there is a substantial overlap in scope between the ESR and the ETS 2 until 2030. For the post 2030 climate target architecture, the review of the interaction of ETS 1 and 2, as well as the ESR and a possible adjustment of the respective scopes is one of the central fields of action. On the one hand, binding national targets under the ESR might potentially conflict with either the demand for increased flexibilities between ETS 1 and ETS 2 or even a full integration of both markets after 2030 in order to increase cost-efficiency (Edenhofer et al. 2021b). The scope of the ESR would become considerably smaller if it were to be restricted to emissions not covered by EU ETS 1 or 2. In this case, responsibilities for achieving emission reduction targets in the buildings and road transport sectors would be shifted from Member States to the EU level to a large extent. Shifting the responsibilities for EU climate policy to the EU, however, could have grave consequences, in case EU policy instruments fail to deliver the necessary reductions on our way to climate neutrality. Also, in such a case it would be much harder to argue for additional national measures to complement EU policies. Therefore, an obvious alternative option would be to continue with national emission reduction obligations for the current ESR sectors allowing some overlap between the ETS and the ESR. This approach would potentially better reflect the important role of Member States for the transition path in these particular sectors. However, the advantages and disadvantages of the degree of interaction between the ESR and the EU ETS 1 and 2 must be further analysed and weighed against each other. Potential interaction and scope adjustments of the ETS 1, 2 and ESR aside, the European Commission needs to ensure that all EU climate targets/emission reduction targets are defined domestically (i.e. for the EU). Cooperative approaches (i.e. accounting of offsets pursuant to Art. 6 mechanisms) should only be used to contribute to additional climate ambition abroad, not to ease the achievement of EU's climate targets.

- **Assess the implications of different approaches for the integration of EU ETS 1 and 2**

[8] Countries included in the ETS1: all 27 EU member states plus Iceland, Norway, Liechtenstein; Countries included in the ESR: all 27 EU member states plus Iceland and Norway.

There were good reasons for keeping the new ETS 2 separate from the "old" ETS 1 under the revised ETS directive at least until 2030. Above all, the responsiveness of the sectors included in these two markets to the carbon price and therefore the steering effect is very different (Braungardt et al. 2022; Zimmer et al. 2022). This is reflected in the very different ambition levels of the two systems for 2030 - while the target in ETS 1 is minus 62% compared to 2005, emissions in ETS 2 only need to be reduced by 42% (though the speed of emission reductions will be higher in ETS 2 from now up to 2030). While ETS 1 covers the energy and industry sector where private business entities seek to optimize their costs and profits, in ETS 2, there are larger market barriers. Abatement decisions are sometimes not guided by cost-optimizing, but for instance by the desire for comfort or status or they are inhibited by split responsibilities, e.g. between tenants and landlords. Private households might also have a smaller price elasticity because moving homes (e.g. to reduce carbon cost due to heating or transport needs) is not easily done and might lead to unacceptable hardships. Some of these reasons for separate markets with different prices and different provisions for price regulation will likely still be true after 2030. If market barriers in the building and transport sectors become less important with increasing decarbonization, both systems should be at least partially integrated in the medium term. This integration opens up scope for increased economic efficiency and at the same time secures liquidity and thus fosters the robustness of the carbon market price signal as the market sizes in EU ETS 1 and 2 continuously decrease. Before the two markets are fully integrated, the European Commission should carefully assess abatement costs and market barriers in these sectors and evaluate the potential steering effect of the carbon price. This review should also consider the option of a step-by-step integration of both systems via limited gateway mechanisms. The technical and regulatory challenges of a combination of an upstream and a downstream ETS must also be examined here.

- **Ensure a high degree of Member States' responsibility for achieving emission reduction targets while strengthening the EU level**

In all sectors, the carbon price cannot do the job of transformation alone, but needs to be accompanied by a smart mix of other instruments. The greatest need for action currently and foreseeably exists in the sectors that are integral part of the current ESR, i.e. the transport, building and agriculture sectors. Member States have an important role there, for instance by investing in new infrastructure in order to provide stakeholders with alternatives for switching to climate-friendly technologies or services or by granting subsidies or incentives. In order to achieve a smooth transition towards a climate-neutral economy in all Member States and to foster cohesion within EU, a robust and ambitious framework of European policy instruments is crucial, but not sufficient. Member states need to be engaged as well and national responsibility for emission reductions (and measures to achieve them) needs to be leveraged. Some Member States will achieve climate neutrality earlier than others – transparency on national deadlines for achieving climate neutrality would be desirable. National targets coexisting with EU wide emissions trading can also prevent that the burden for emission reductions is shifted to countries with less purchasing power. The national targets reflect that Member States have different capacities and ensures fairness because higher income Member States take on more ambitious targets than lower income Member States. At the same time, a strong and ambitious ETS 2 and the flexibilities for national target achievement under the ESR favour a market-price driven and economically cost-efficient allocation of reduction efforts at EU level. Moreover, interstate trade within the framework of the ESR incentivises additional reduction efforts by member states with less ambitious targets. In this respect, national emission reduction targets under the ESR and EU wide emissions trading can coexist and the European Commission should

evaluate options for prolonging this coexistence beyond 2030 and extending the coverage of national targets to the whole economy.

- **Assess the potential benefit of (indicative) sectoral targets**

All sectors must contribute to achieving climate neutrality. There are few sectors with unavoidable (at the moment) emissions that need to be offset by negative emissions. It is therefore important that all sectors follow a clear transformation pathway and not rely on buying emission allowances. Sectoral targets might therefore be important to ensure that no sector delays the necessary transformation. Sectoral targets could be helpful for providing planning security for sectoral stakeholders, assigning clear responsibilities for policy makers and allowing targeted policy readjustments if sectoral progress is underperforming. The ECL could define indicative targets for each sector (e.g. energy, industry, transport, buildings and waste) and oblige the European Commission to propose additional measures if emissions in a sector are higher than the indicative sectoral emission reduction pathway. Sectoral targets could make sense in particular in a scenario where ETS 1 and 2 were integrated while binding national targets for the Effort-Sharing sectors were no longer applicable or only for a small part of the economy. In contrast, if ETS 1 and ETS 2 are not integrated and national targets in the ESR are maintained, supplementary sector targets appear significantly less urgent and could lead to an unnecessary complexity of the climate protection architecture and endanger the cost-efficient allocation of emission reductions.

6 Understand the 2040 target as a process, not a single year target

The current EU climate target of reducing net emissions by minus 55%, compared to 1990, falls short of the UBA recommendation of at least 60% emission reduction by 2030 and is probably insufficient to be considered as in line with the Paris Agreement (Burger et al. 2020). Under current legislation, the negative emissions in the order of 310 Mt CO_2 required by the LULUCF regulation cannot fully be accounted for to EU's climate target, as suggested by former Commissioner Frans Timmermans, because the contribution of (natural) carbon sinks to the 2030 climate target has been limited to 225 Mt CO_{2eq} in the ECL (Regulation (EU) 2021/1119, Art. 4 (4)). With this limitation to accounting for negative emissions from natural sinks European lawmakers wanted to ensure that the focus is on emission reductions and address concerns about uncertain permanence of natural sinks. For raising the target beyond 55% emission reductions, this limitation would need to be removed or ambition in reducing gross emissions would need to be increased.

- **Frame and communicate the 2040 target as process that starts now and establish a regular review mechanism**

While setting a target for 2040 is necessary to align all transformation efforts towards the goal of achieving climate neutrality by 2050, there is still more than 15 years between the adoption of the Fit for 55 package and the year 2040. For minimizing cumulative emissions, it is crucial to focus on early action and accelerate emission reductions in the near future. Postponing efforts to later years, in the hope that technological progress and more time will make the decarbonisation and transformation of all sectors easier, has to be avoided. We therefore propose to understand setting the target for 2040 as a process that starts already in the mid-2020. The ECL should define dates and mechanisms for reviewing (and tightening) the 2030 and 2040 targets.

- **Set a schedule for reviewing and potential tightening the 2030 emission reduction target to 60%**

Combined with the REPowerEU initiative, the legislative framework of the Fit for 55 package will likely be overachieving the current 2030 target of minus 55% net emission reduction. The accelerated measures for weaning off of fossil fuels are not implemented in the form of higher binding targets for the ESR and the EU ETS 1 and 2, though, as they are designed to achieve approx. 53% gross emission reductions only. As the legislative framework has just been determined in form of the Fit for 55 package, another revision of the legislation is not likely before mid of this decade. Considering the urgency for climate protection and the EU's global leadership role, the UBA has advocated for setting the 2030 GHG emission reduction target to a minimum of 60% by 2030. This need is underscored in the UBA study titled "Raising the EU 2030 GHG Emission Reduction Target" (Burger et al. 2020). In this study, the UBA discusses enabling conditions that can facilitate these emissions reductions and providing options to achieve the ambitious 60% GHG emission reduction goal.

- **Install a stocktaking and review process for the 2040 target mid of the next decade**

When the European Commission will propose a target for 2040 in the first half of 2024, 2040 is still more than 15 years away. A robust mechanism is therefore necessary to evaluate this target against actual progress in emission reductions, the availability and market uptake of climate-neutral technologies, infrastructure and behavioural changes. The ECL should define a date and

a process for taking stock and reviewing the 2040 target with a view to enhancing its ambition in the mid of the next decade, e.g. in the years 2034 or 2035.

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List of abbreviations

Advisory Board	European Scientific Advisory Board on Climate Change
BECCS	Bioenergy with Carbon Capture and Storage
CCUS	Carbon Capture, Use and Storage
CO_2	Carbon dioxide
DACCS	Direct Air Capture and Storage
ECL	European Climate Law
ESR	Effort Sharing Regulation (Climate Action Regulation)
EU ETS	EU Emissions Trading System
EU ETS 1	Existing EU ETS (energy, energy intensive industry, aviation, maritime)
EU ETS 2	New EU ETS starting from 2027 (buildings, road transport, industry)
GHG	Greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land, land use change and forestry
MRV	Monitoring, Reporting, Verification
UBA	German Environment Agency
UNFCCC	United Nations Framework Convention on Climate Change