NDC ASPECTS

Submission

Ensuring an Effective Global Stocktake with a Sectoral Perspective

August 2022

Submission by the Wuppertal Institute
on behalf of the NDC ASPECTS Project

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

Executive Summary

A sectoral perspective can help the Global Stocktake (GST) to effectively achieve its objective to inform Parties' in enhancing subsequent NDCs and in enhancing international cooperation. Specifically, granular and actionable sectoral lessons, grounded in country-driven assessments, should be identified and elaborated. To be effective, conversations on sectoral transformations need to synthesise key challenges and opportunities identified in the national analyses and link them to international enablers; focus on systemic interdependencies, involve diverse actors, and be thoroughly prepared including by pre-scoping points of convergences and divergence across transformations. We specifically recommend that:

- the co-facilitators of the Technical Dialogue use their (limited) mandate to facilitate an effective conversation on sectoral transformations e.g. by organising dedicated informal seminars in between formal negotiation sessions;
- key systemic transformations necessary to achieve net-zero by mid-century should be spelled out and included in the final decision or political declaration of the GST; and
- the political outcome of the GST should mandate follow-up processes at the regional level and encourage national-level conversations to translate the collective messages from GST into actionable and sector-specific policy recommendations.

Moreover, the GST can further support NDC enhancement by endorsing key scientific benchmarks for achieving the 1.5°C goal of the Paris Agreement. These benchmarks can then be employed by stakeholders as an indicative yardstick to assess draft NDCs before adoption. Building on our own analysis of global model results, we propose key benchmarks in selected sectors (see table).

Sector	Indicator	Benchmark
Power	Share of coal in power generation	Near zero by 2030 in developed and 2040 in developing countries.
	CO_2 emissions per unit of electricity	150 grCO_2/kWh in 2030, and zero ideally before 2050.
	Share of renewables in electricity generation	50% in 2030 and at least 70-80% in 2050.
Industry	Global CO_2 emissions from industry	-27% by 2030 and -70% by 2050 relative to 2010.
	Share of electricity in industrial energy consumption	30% in 2030 and at least 50% in 2050.
Transport	Global transport CO_2 emissions	Stabilise at current levels through 2030 and decline to -50% by 2050 relative to 2010.
	Share of electricity in total transport energy consumption	5% in 2030 and further and up to 15-30% by 2050.
	Share of non-fossil fuels in domestic-only transport energy consumption	90-100% by 2050.
Buildings	Global CO_2 emissions from buildings	-25% by 2030 and -70% in 2050 relative to 2010.
	Share of electricity in buildings' energy consumption	45% in 2030 and 65-70% in 2050.
AFOLU	land required per year for net afforestation	~2 million ha annually between 2030 and 2050.

Likewise, a sectoral perspective included in the GST may inform enhanced international cooperation by closing important governance gaps. Specifically, we recommend that

- Parties should voluntarily report on sectoral transformation challenges, including economic, financial, technical, political/institutional and capacity-related barriers. The modalities, procedures and guidelines to the Enhanced Transparency Framework should be revised at the next occasion to include a mandate to do so.
- the outputs of the GST should identify and summarise key opportunities for sectoral climate governance sector by sector and call on other international organisations to exploit the identified opportunities as appropriate.
- Parties to the Paris Agreement use the GST to send a signal to other intergovernmental institutions, including the ICAO and IMO, requesting periodic reports in which these institutions indicate not only what measures have been adopted, but also how those measures are aligned with the Paris Agreement's long-term goals.

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

Introduction

Achieving the objectives of the Paris Agreement requires a fundamental transformation of global societies and economies (IPCC, 2022) and focusing on effective and coordinated action. Our economies are underpinned by a patchwork of interrelated and interdependent sectoral systems, each supplying distinct goods and services such as energy, transport and mobility, agricultural products and food, residential and commercial buildings, or industrial products. Sectoral transformations are urgently needed and will involve changes in institutions, infrastructure, markets, business models, and social customs. Each sectoral system is distinct in its political economy, technologies, financing structures and industrial composition, and the nature and extent of its international connectedness. Each sectoral system requires its own transformation, and barriers to, and opportunities for transformation vary strongly from sector to sector.

To be effective, climate policy therefore needs to recognise and address sectoral specificities (Oberthür et al., 2021; Rayner et al., 2021; Victor et al., 2019), and take into consideration the interlinkages between sectors. Sectoral perspectives allow us to connect the national to the global level by recognising the systemic interrelations across national borders. It highlights the imperative and the potential of international cooperation on climate change mitigation, which will fail without adequate institutional capacity at all levels (IPCC, 2022). The application of sectoral lenses facilitates the understanding of individual countries' contributions to global transformation in each of the sectoral systems while exposing local actors to the differences that arise from national versus global perspectives on a sector-specific decarbonisation strategies (Torres Gunfaus & Waisman, 2021). Ultimately, successful implementation of climate policies must inevitably address and enable sectoral transformations occurring at the national level.

What is a "sectoral system"?

Sectoral systems provide identifiable societal functions such as transport, electricity, or raw materials for industrial production. They are constituted of ensembles of actors (corporations, administrative bodies, political groups/parties, international organisations), technologies and infrastructures, economic structures, institutions and ideas that produce degrees of path dependency and resistance to change. Sectoral systems are complex in the sense that they (1) produce emergent phenomena/effects that are more than the sum of the systems' parts, and (2) they are open, i.e. closely related to and potentially overlapping and interdependent with other sectoral systems.

Source: Oberthür et al. (2021).

In the run-up to and during the first technical dialogue (TD) of the Global Stocktake (GST) many Parties and observers pointed to the need for a sectoral perspective.[1] However, to date, the UNFCCC has been ill-equipped to introduce sectoral perspectives. Historically, negotiations under the UNFCCC were not held along sectoral lines, with very few exceptions[2] that have had only limited impact in moving forward sector transformations. Moreover, the GST modalities adopted at COP24 in Katowice provide only very limited time and no explicit mandate for sectoral discussions. Notwithstanding these constraints, sectoral approaches grounded in country-driven assessments could be key to maximizing the GST's efficacy with respect to informing national action while enhancing international cooperation. In the margins of the multilateral negotiations by countries sector-oriented pledges are emerging supported by multiple actors (governments, business, etc.), showing the importance of sectoral perspectives.

[1] See for instance submission by Switzerland on behalf of the Environmental Integrity Group (dated 13 April 2022).

[2] For example, the negotiations of issues related to REDD+ and the Koronivia Joint Work on Agriculture.

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

With a focus on mitigation, this submission highlights ways in which addressing bottom-up and sector-specific transformation challenges can help GST discussions to progress within the limitations of its mandate. According to Article 14.3 of the Paris Agreement, the GST has a dual mandate to inform Parties (1) in enhancing and updating their national actions and support and (2) in enhancing international cooperation. This submission is structured accordingly, first highlighting the ways in which the GST might effectively link to national level policy processes towards developing and adopting NDCs and, second, highlighting gaps in the existing global climate governance landscape and suggesting ways that the GST may contribute to closing those gaps with a sectoral perspective.

In doing so, this submission responds to the following overarching questions:

- What information is required (ICP guiding question 6) and what action needs to be taken to overcome barriers and challenges to transformations to ultimately enhance ambition (TA guiding question 5)?
- Which opportunities exist to enhance international cooperation and governance to create an enabling international environment for deep transformations (ICP guiding question 32; TA guiding question 22)?
- What is the role of diverse actors for the transformation of key sectoral systems (related to TA guiding question 21)?

Enhancing National Ambition in Subsequent NDCs

The GST is a central cog in the ambition cycle of the Paris Agreement. It establishes a feedback loop connecting the national-level implementation of NDCs with the overarching global long-term goals of the Paris Agreement with a view to influencing and inspiring national agendas towards more ambitious subsequent NDCs and enhancing international cooperation. In the logic of a results change framework, the immediate outputs of the GST are supposed to lead to informed policy processes towards new NDCs at the national level. The intended impact of this logic is that these policy processes result in enhanced ambition. But how can this be best achieved? How can we support the actual unfolding of this logical chain?

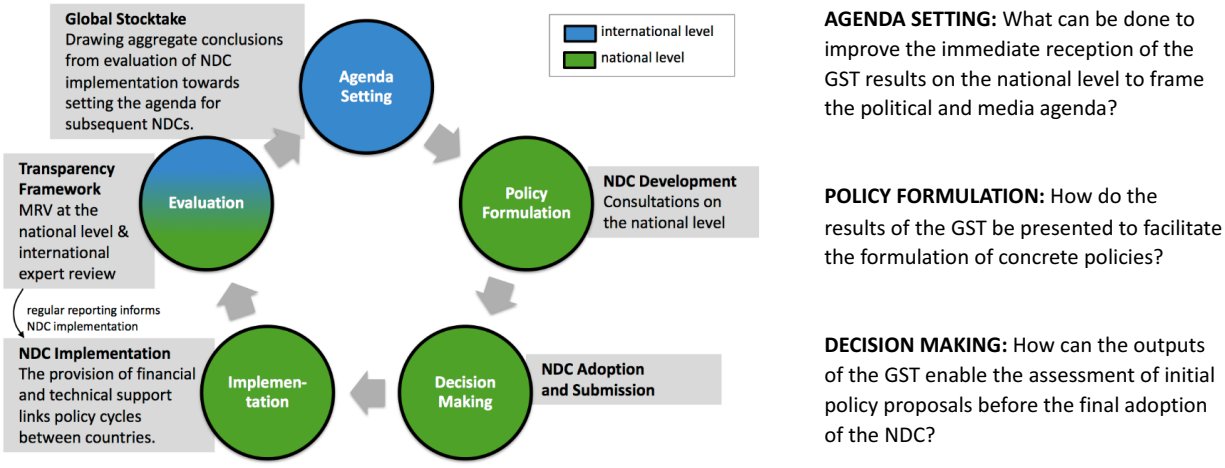


Figure 1 **How can the GST influence the NDC policy cycle at the nation level?**
Source: adapted from Hermwille et al. (2019)

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

We argue that the GST can influence the national NDC policy process at three distinct stages: agenda setting, policy formulation and decision making (Figure 1). For the agenda-setting phase, the political profile of the GST is particularly important. Participation at the heads-of-state level will raise public attention and increase the chances that stakeholders at the national and sectoral level can use the international event as a fulcrum to leverage political discourse towards the development of a more ambitious NDC also at the national level. In the following, we will develop specific recommendations on how the outputs of the GST should be designed to effectively resonate with the NDC process at the national level with a special focus on the policy formulation and decision-making phases.

Informing policy formulation for NDCs

It has been argued that the GST may become a platform for transformational learning requiring not only factual learning through the aggregation and assessment of new data but also collective meaning making related to those data in the light of national experiences and changing values (Milkoreit & Haapala, 2018). To be effective in this regard, the right lessons need to be identified and they need to be processed in a way so that they are actually learnt, i.e. picked up and adequately reflected in actual behavioural change, notably by way of inclusion in subsequent NDCs. Again, we argue that a sectoral perspective can facilitate this process by providing necessary granularity and practical and actionable detail.

The GST's mandate and modalities do not provide an explicit space for focused conversations on specific sectoral systems and their respective transformation challenges. However, the chairs of the TD have some leeway in designing the process. During the first session of the TD the formal roundtables were less effective in leveraging a genuine dialogue. Parties often repeated well-known negotiation positions and their broad thematic scope was not conducive to enabling a focused discussion of specific transformation drivers and barriers. Instead, the world café event was more effective in this regard. **We recommend that the co-facilitators of the TD use their (limited) mandate to facilitate an effective conversation on sectoral transformations e.g. by organising dedicated informal seminars in between formal negotiation sessions. These seminars should focus on specific sectoral transformation challenges such as for instance the challenges for decarbonising freight transport, access to and cost of international capital for renewable energy deployment, or the decarbonisation of primary iron- and steelmaking.**

Moreover, the material collected during the ICP phase and the first technical dialogues should already suffice to identify selected key systemic transformations and their international enablers. Building on the sector-specific seminars proposed above, it should be possible to **spell out those key systemic transformations necessary to achieve net-zero by mid-century for inclusion in the final decision or political declaration of the GST. These transformations should be grounded in the latest science, and be able to speak directly to real world actors, in a way that they can send a signal to speed up the transition.**

Due to the limitations of its mandate, we cannot assume that the GST will address sectoral transformations at sufficient level of detail. Moreover, global trends need to be revisited in the light of national and regional circumstances to be effectively picked-up in policy formulation. **We therefore recommend that the political outcome of the GST should mandate follow-up processes at the regional level and encourage national level conversations to translate the collective messages from GST into actionable and sector-specific policy recommendations. This follow-up should build on and further elaborate the global climate action pathways developed under auspices of high-level champions and draw on the existing regional climate weeks as appropriate and hold similar events in regions that are not yet covered.**

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

Conditions for successful conversations on sectoral transformations

Taking advantage of experiences made during the sectoral conversations of the NDC ASPECTS research project we have identified four key conditions for success in advancing effective conversations.

Synthesise key challenges and opportunities identified in the national analyses and link them to international enablers: Obviously, the specific circumstances vary substantially between countries. While not all differences can be adequately addressed, information on the socio-economic and distributional effects of the transformations and on the barriers to the scale up of action, given the key challenges and opportunities identified in the national analyses is key (Fazekas et al., 2022). From this, global conditions can be distilled that could help overcome the barriers and support increases in climate ambition and can also guide priorities of international cooperation. The GST represents a unique opportunity to discuss these international enablers of national transformations towards net zero.

Focus on systemic interdependencies: Most current national mitigation strategies are focusing efforts on technological aspects of decarbonisation transitions. While these are necessary, they will suffice to reach global carbon neutrality. The scientific community already warned that many other options, such as demand-side solutions, should be taken into account (IPCC, 2022); and that technological change could not be seriously implemented without taking into account the overall societal transformations in which it should take place (IPCC, 2018b). Misconceptions still exist on the nature of national and systemic transformations required by global carbon neutrality. For example, in the transport sector, the focus is often given to technological energy efficiency measures (SLOCAT, 2021) or the change of vehicle motorisation and fuel supply, which are not sufficient at all to reach carbon neutrality. For instance, in freight transfer, the transformations of the production and consumptions systems need to be considered to unlock the full mitigation potential (Briand & Waisman, 2019). To be effective, conversations on sectoral transformations need to embrace those wider systemic interdependencies.

Involve diverse actors: Current international climate dialogues often focus on public policy perspectives and have difficulties in offering a fair and equal representation to national challenges in the Global North and South (Beuermann et al., 2021). However, system transitions for global carbon neutrality require by definition the coordination of multiple decisions taken by countries, but also by non-state actors, regions, cities, companies, and citizens, and so on, in different but interconnected worldwide regions (IPCC, 2022). Discussing a specific transformation and related enablers, therefore, requires gathering the relevant participants who could share specific domestic perspectives on implementation challenges and those who could act on the specific enablers. Representing scientific perspectives from the Global South alongside the hitherto dominant Northern voices may close important gaps and broaden the scientific evidence base for the conversations.

Thoroughly prepare conversations: Aside from the relevant actors for the discussion, it is crucial to develop a strategy for the conversation, playing on the positions of different actors and relations among them, to help catalyse reactions, reveal threats and opportunities, and prepare the ground for effective and constructive dialogues around trade-offs embedded in different courses of actions and policy solutions that navigate the trade-offs while maximising synergies and benefits to actors involved. For that, the work of experienced facilitators is key: they should be nominated at least a month in advance of each conversation, and be required to coordinate with key participants beforehand to be able to extract the most of the discussions. This pre-dialogue scoping could notably identify points of convergences and key points of divergence across transformations, so that the TDs can crystallise the former and allow progress on the latter through a facilitated and well-prepared exchange.

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

Supporting decision making towards adopting ambitious NDCs

The GST needs to provide clear benchmarks at the sectoral level that national-level stakeholders can employ as a yardstick to gauge the adequacy and ambition of their government's (draft) NDCs. The adoption of a new NDC is a highly political process. Our research shows that transparent and open participatory processes in the development of NDCs as well as a high level of democratically legitimised scrutiny is a key determinant of high NDC ambition (Peterson et al., forthcoming). The question is, how can this kind of involvement of stakeholders and civil society more broadly be facilitated effectively? Much like the 1.5°C temperature goal has empowered civil society actors such as the Fridays for Future movement, the outputs of the GST might provide an important point of reference and legitimation. However, a condition for that is that the GST elaborates and endorses relatively granular guidelines on where we need to be, not only in 2050 but also in 2030, the corresponding time horizon for subsequent NDCs. The more granular, comprehensive and differentiated those benchmarks are, the more useful they become for stakeholders to assess policy proposals. Since the GST's mandate is limited to "collective progress" and country-specific benchmarks are explicitly precluded, sectoral granularity can be a useful way forward.

Building on a detailed analysis (see annex) of latest climate change mitigation scenarios contained in the global scenario database for the 6th Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC, 2022) as well as selected benchmark studies (IEA, 2021; JRC, 2021; Shell, 2021; Teske, 2019), we propose a series of key global-level sectoral performance benchmarks.

The **power sector** is at the forefront of the low-carbon transition, demonstrated by the upscaling of renewable energy technologies and their rapid cost reductions. In addition, action in the power sector has a high priority as it directly enables the successful decarbonisation of the other demand sectors, including heat demands, moving from fossil fuels to clean electricity where possible (e.g. through electric vehicles, heat pumps, electrification of industrial processes, etc.). To achieve the 1.5°C goal, the sector must achieve the following global benchmarks:

- The share of coal in power generation needs to be reduced to (close to) zero by 2030 in developed countries and by 2040 in developing countries at the very latest.
- CO_2 emissions per unit of electricity need to be reduced to ~150 $grCO_2$/kWh in 2030, and zero before 2050.
- The share of renewables in electricity generation should increase to about 50% in 2030 and further to 70-80% in 2050. Some scenarios (e.g. IEA) even project renewable energy shares to increase to more than 90% by 2050 assuming limited use of other low-emission options.

The **energy-intensive raw material industries** are often considered to be particularly hard to abate. Key challenges include the limited availability and high costs of low-emission options, while increased energy costs may also raise competitiveness issues leading to trade losses in international markets. Massive research and development for, and upscaling of new decarbonisation options is required. Where electrification of industrial processes is not possible, technologies such as hydrogen-based direct reduced iron, hydrogen as a feedstock for the chemical industry, CCS, CCU, synthetic fuels, or industrial symbiosis need to be initiated before 2030. Overall, to meet the 1.5°C goal:

- Emissions from the industry sector must decline by about 27% by 2030 and 70% by 2050 relative to 2010 levels; some scenarios even achieve close to 100% decline.
- The share of electricity in energy consumption of industry needs to increase to around 30% in 2030 and further to 50% in 2050.

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

The **transport sector** needs to revers historic trends with rapidly increasing transport-related emissions as a result of rapid motorisation globally, growing mobility activity and transport volumes, and heavy reliance on oil products. This can be achieved by a combination of reducing induced mobility needs (avoid), using more sustainable and efficient modes of transport (shift) and improving technical efficiency and converting to efficient low-carbon fuels such as electricity and hydrogen/synthetic fuels where necessary (improve). For a 1.5°C compatible pathway:

- Despite rapidly increasing motorisation rates and mobility activity, global transport CO_2 emissions must stabilise at current levels through 2030 and decline to -50% by 2050 relative to 2010, achieving close to 90-100% reduction in some scenarios.
- The share of electricity in total transport energy consumption needs to quintuple to more than 5% in 2030 and further increase to 15-30% by 2050 (close to 50% in some scenarios). Specifically, the share of non-fossil fuels in domestic-only transport energy consumption (electricity, hydrogen, synthetic fuels) should increase close to 90-100% by 2050.

The **buildings sector** is set for a rapid expansion, especially in developing countries as a result of increasing income, improved living standards and comfort, and population growth. To be compatible with the 1.5°C goal:

- CO_2 emissions from buildings must decline by 25% by 2030 from 2010 levels, and 70% in 2050. Recent net-zero scenarios from international organisations suggest even larger reductions of 90-100% by 2050.
- The share of electricity in buildings' energy consumption must increase rapidly from the current 30% to about 45% in 2030 and further to 65-70% in 2050.

Agriculture, forestry and land-use (AFOLU) contribute to climate change in diverse ways. Agriculture (A) sub-sector is a source of GHG emissions, while the Forestry and Other Land Use (FOLU) sub-sector is both a source and a sink of GHGs. Land-based mitigation options received increased attention including by the IPCC (2018a) because of its CO_2 removal potential. Yet, our analysis shows that when considering the net emissions and removals of CO_2 and non-CO_2 gases, AFOLU remains a source for 2030 and 2050 even in ambitious 1.5°C scenarios due to non-CO_2 emissions. The complexities of the AFOLU sector are poorly represented in integrated assessment models, and historical and present emissions data are still not good enough, although new harmonised datasets are emerging that could be used in coming years to improve predictions and align bottom-up and top-down estimates (Grassi et al., 2022). Despite significant uncertainties, it is clear that significant afforestation is required to leverage the sink potential. To achieve the 1.5°C goal:

- ~1.2 million ha of land per year are required for net afforestation up to 2030, and ~2 million ha per year from 2030 to 2050. Though, some 2°C scenarios rely more heavily on the sink potential of forests and require up to 8 million ha of land annually by 2050.

Obviously, a global temperature goal cannot unambiguously be translated into individual actions at the sectoral level. Different strategies and routes could be used to meet the long-term goal, for instance by assigning more reductions to specific sectors, as long as the overall emissions budget is met (since the overall carbon budget determines the long-term temperature change). However, the degree of freedom is limited, as the available emissions budget is small, especially if we consider the 1.5°C goal. In the long run, the differences between sectors disappear and all sectors need to reach net zero emissions eventually.

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

We recommend that the synthesis report on the outcome of the technical assessment component of the GST includes global sector performance benchmarks based on the above analysis or other best available science. Moreover, we recommend that Parties endorse those performance benchmarks also during the political consideration of outputs and include a clear reference to those benchmarks in the final COP decision or political declaration.

Enhancing International Cooperation

Apart from informing national actions and supporting subsequent NDCs, the GST has also been mandated to inform the enhancement of international cooperation. This refers both to international cooperation under the UNFCCC (e.g., under the umbrella of Article 6), as well as cooperation outside of its auspices. In addition to the UNFCCC and the Paris Agreement, a growing number of inter- and transnational institutions govern various aspects of climate change, many of which address specific sectoral issues. The question is how to harness this broader global climate governance landscape to support sectoral climate action and the achievement of the Paris Agreement's long-term goals (Betsill et al., 2015).

Encourage systematic reporting of sectoral transformation challenges

Within the UNFCCC, we have identified one particular gap. Transforming sectoral systems to the extent necessary is extremely hard and developed and developing countries alike routinely face economic, financial, technical, political/institutional or capacity-related challenges. However, these challenges are not systematically evaluated and reported under either the existing UNFCCC reporting and review system or the Paris Agreement's enhanced transparency framework (Jeffery et al., 2021). Including such information systematically at the level of key sectoral systems in Parties' biennial transparency reports would enable to identify shared challenges, discern effective policies and measures to overcome specific transformation challenges, and thus enable learning. This, in turn, could form an important input into the GST.

We therefore recommend that Parties should voluntarily report on sectoral transformation challenges they are facing. Moreover, Parties should call for a revision of the reporting requirements to include a mandate for Parties to systematically report sector-specific transformation challenges including economic, financial, technical, political/institutional and capacity-related barriers.[3]

Leverage global governance to address transformation barriers and enablers sector by sector

As at the national level, a sectoral perspective is also helpful to identify how international cooperation can work most effectively. A sectoral perspective allows to pinpoint enablers and barriers and thereby makes it possible to identify the most promising route of action. Yet, significant potential for global governance remains underexploited (Rayner et al., 2021). Distilling key international enablers and shared transformation barriers from the material

[3] The formal revision of the Modalities, Procedures and Guidelines for the Enhanced Transparency Framework are only due to be revised in 2027. This, however, would be too late to have an effect on the second Global Stocktake scheduled for 2028.

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

gathered in the ICP and TD phases of the GST may provide inspiration and legitimation for other international institutions to enhance their governance approaches tailored to the specific needs and opportunities of each sector. Table 1 below illustrates this by listing options for enhanced global governance for the steel industry and transport sector.

We therefore recommend that the outputs of the GST should identify and summarise key opportunities for sectoral climate governance sector by sector and call on other international organisations to exploit the identified opportunities as appropriate.

Table 1 **Selected options for enhanced international cooperation in the steelmaking and transport.** *Synthesised from Hermwille et al (2022) and Obergassel et al. (2021).*

Steel	• establishing a credible labelling or certification scheme for low-emission steel, combined with an independent auditing and compliance mechanism; • creation of lead markets through coordinated public and private procurement and dynamic but limited subsidies enabled through carbon contracts for difference; • an international moratorium on (re-)investments in conventional unabated steel making facilities from e.g. 2025
Transport	• International coordination of vehicle regulations and phase-out dates for conventional vehicles to accelerate market transformation. • Provision of international support for developing countries to establish the necessary charging infrastructure and improve electricity supply to cope with increasing loads and shifts in the demand profile. • Generally, shift all international financing from high-emission to low-emission transport modes.

Align activities by sectoral institutions and organisations with Paris goals

International cooperation at the sectoral level consists of a variety of informal cooperative initiatives through which sectoral emissions are addressed, involving governments, businesses and other actors (e.g., the Industrial Deep Decarbonisation Initiative, the Forest Declaration Platform, the SLOCAT Partnership on Sustainable Low Carbon Transport). However, some sectoral emissions are directly addressed by other intergovernmental institutions. The most prominent of these are emissions from international aviation and international shipping, which are tackled by the International Civil Aviation Organization (ICAO) and International Maritime Organization (IMO) respectively. Some progress has been made in these institutions. The IMO has adopted an Initial GHG Strategy, which aims for a 40% reduction in carbon intensity by 2030 and pursuing efforts towards a 70% reduction by 2050 (compared to 2008 levels). Moreover, the organisation has adopted several short-term measures, including an Energy Efficiency Ship Index and a carbon intensity reduction requirement for shipowners. Although ICAO has not set a long-term target – one is under consideration at its next Assembly in September 2022 – it adopted a market-based mechanism – the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) – in 2016. Although both ICAO and IMO regularly submit statements and reports to the UNFCCC, these do not include any indication of how the efforts by these institutions contribute to the long-term goals of the Paris Agreement, even though emissions in these two sectors are projected to increase significantly in the coming decades.

We therefore recommend that Parties to the Paris Agreement use the GST to send a signal to other intergovernmental institutions by requesting periodic reports in which these institutions indicate not only what measures have been adopted, but also how those measures are aligned with the Paris Agreement's long-term goals.

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

References

Betsill, M. M., Dubash, N. K., Paterson, M., van Asselt, H., Vihma, A., & Winkler, H. (2015). Building Productive Links between the UNFCCC and the Broader Global Climate Governance Landscape. Global Environmental Politics, 15(2), 1–10. https://doi.org/10.1162/GLEP_a_00294

Beuermann, C., Obergassel, W., van Asselt, H., Häntzschel, M., & Petersmann, M. (2021). Maximising the Impact of the Global Stocktake: Options for Design and Implementation [NDC ASPECTS Policy Brief]. Wuppertal Institute for Climate, Environment and Energy & University of Eastern Finland. https://www.ndc-aspects.eu/sites/default/files/2021-10/GST_Policy_Brief_fin.pdf

Briand, Y., & Waisman, H. (2019). Enhancing the ambition of NDCs through the analysis of sectoral transformations: The example of freight transport (Issue Brief No. 14/19; p. 4). IDDRI. https://www.iddri.org/en/publications-and-events/issue-brief/enhancing-ambition-ndcs-through-analysis-sectoral

Churkina, G., Organschi, A., Reyer, C. P. O., Ruff, A., Vinke, K., Liu, Z., Reck, B. K., Graedel, T. E., & Schellnhuber, H. J. (2020). Buildings as a global carbon sink. Nature Sustainability, 3(4), 269–276. https://doi.org/10.1038/s41893-019-0462-4

Fazekas, A., Bataille, C., & Vogt-Schilb, A. (2022). Achieving Net-Zero Prosperity: How Governments Can Unlock 15 Essential Transformations (2022nd ed.). IDDRI, IDB. https://doi.org/10.18235/0004364

Grassi, G., Conchedda, G., Federici, S., Abad Viñas, R., Korosuo, A., Melo, J., Rossi, S., Sandker, M., Somogyi, Z., & Tubiello, F. N. (2022). Carbon fluxes from land 2000-2020: Bringing clarity on countries' reporting (pp. 1–49) [Earth System Science Data]. Copernicus GmbH. https://essd.copernicus.org/preprints/essd-2022-104/

Griscom, B. W., Adams, J., Ellis, P. W., Houghton, R. A., Lomax, G., Miteva, D. A., Schlesinger, W. H., Shoch, D., Siikamäki, J. V., Smith, P., Woodbury, P., Zganjar, C., Blackman, A., Campari, J., Conant, R. T., Delgado, C., Elias, P., Gopalakrishna, T., Hamsik, M. R., … Fargione, J. (2017). Natural climate solutions. Proceedings of the National Academy of Sciences, 114(44), 11645–11650. https://doi.org/10.1073/pnas.1710465114

Hermwille, L., Lechtenböhmer, S., Åhman, M., van Asselt, H., Bataille, C., Kronshage, S., Tönjes, A., Fischedick, M., Oberthür, S., Garg, A., Hall, C., Jochem, P., Schneider, C., Cui, R., Obergassel, W., Fragkos, P., Sudharmma Vishwanathan, S., & Trollip, H. (2022). A climate club to decarbonize the global steel industry. Nature Climate Change, 12, 494–496. https://doi.org/10/gp664g

IEA. (2021). World Energy Outlook 2021. International Energy Agency. https://www.iea.org/reports/world-energy-outlook-2021

IPCC. (2018a). Climate Change and Land: An IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. Intergovernmental Panel on Climate Change (IPCC). https://www.ipcc.ch/srccl/download/

IPCC. (2018b). Global Warming of 1.5°C – Summary for Policy Makers. Intergovernmental Panel on Climate Change (IPCC). http://www.ipcc.ch/pdf/special-reports/sr15/sr15_spm_final.pdf

IPCC. (2022). Climate Change 2022: Mitigation of Climate Change. Intergovernmental Panel on Climate Change (IPCC). https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_FinalDraft_FullReport.pdf

JRC. (2021). Global energy and climate outlook 2021: Advancing towards climate neutrality : taking stock of climate policy pledges after COP26 and the corresponding energy economy implications. Publications Office of the European Union. https://data.europa.eu/doi/10.2760/410610

Milkoreit, M., & Haapala, K. (2018). The global stocktake: Design lessons for a new review and ambition mechanism in the international climate regime. International Environmental Agreements: Politics, Law and Economics. https://doi.org/10.1007/s10784-018-9425-x

Obergassel, W., Lah, O., & Rudolph, F. (2021). Driving towards transformation? To what extent does global climate governance promote decarbonisation of land transport? Earth System Governance, 8. https://doi.org/10.1016/j.esg.2021.100098

Oberthür, S., Hermwille, L., & Rayner, T. (2021). A sectoral perspective on global climate governance: Analytical foundation. Earth System Governance, 8, 100104. https://doi.org/10.1016/j.esg.2021.100104

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

Peterson, L., van Asselt, H., Hermwille, L., & Oberthür, S. (forthcoming). The Determinants of Ambition? Analysing NDC Enhancement with a Mixed-method Design (NDC ASPECTS Deliverable D4.1).

Rayner, T., Oberthür, S., & Hermwille, L. (2021). A sectoral perspective on international climate governance: Key findings and research priorities. Earth System Governance, 8. https://doi.org/10.1016/j.esg.2021.100105

Roe, S., Streck, C., Obersteiner, M., Frank, S., Griscom, B., Drouet, L., Fricko, O., Gusti, M., Harris, N., Hasegawa, T., Hausfather, Z., Havlík, P., House, J., Nabuurs, G.-J., Popp, A., Sánchez, M. J. S., Sanderman, J., Smith, P., Stehfest, E., & Lawrence, D. (2019). Contribution of the land sector to a 1.5 °C world. Nature Climate Change, 9(11), 817–828. https://doi.org/10.1038/s41558-019-0591-9

Shell. (2021). The Energy Transformation Scenarios. https://www.shell.com/transformationscenarios

SLOCAT. (2021). Climate Strategies for Transport: An Analysis of Nationally Determined Contributions and Long-Term Strategies. Partnership for Sustainable, Low Carbon Transport. https://slocat.net/wp-content/uploads/2022/01/Climate-Strategies-for-Transport-An-Analysis-of-NDCs-and-LTS-SLOCAT-December-2021.pdf

Teske, S. (2019). Achieving the paris climate agreement goals: Global and regional 100% renewable energy scenarios with non-energy GHG pathways for +1.5c and +2c. Springer Berlin Heidelberg.

Torres Gunfaus, M., & Waisman, H. (2021). Assessing the adequacy of the global response to the Paris Agreement: Toward a full appraisal of climate ambition and action. Earth System Governance, 8, 100102. https://doi.org/10.1016/j.esg.2021.100102

Ürge-Vorsatz, D., Khosla, R., Bernhardt, R., Chan, Y. C., Vérez, D., Hu, S., & Cabeza, L. F. (2020). Advances Toward a Net-Zero Global Building Sector. Annual Review of Environment and Resources, 45(1), 227–269. https://doi.org/10.1146/annurev-environ-012420-045843

Victor, D. G., Geels, F. W., & Sharpe, S. (2019). Accelerating the Low Carbon Transition – The case for stronger, more targeted and coordinated international action (p. 140). www.energy-transitions.org/sites/default/files/Accelerating-The-Transitions_Report.pdf

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

ANNEX: Detailed Analysis of Key Global Sector Benchmarks

Based on a detailed assessment of the latest climate change mitigation scenarios contained in the scenario database for the 6th Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC, 2022), representing the best available science today, and key international benchmark studies from international organisations, industry and academia (IEA, 2021; JRC, 2021; Shell, 2021; Teske, 2019), we propose a series of key global-level sectoral performance benchmarks.

The Paris Agreement's temperature goal means that all sectors and countries will eventually have to reduce emissions to net- zero, with the main questions being when and how. To inform policy improvements and to monitor the state of transformational change – whether it is already underway, or more action is required – we need more granular information. Sectoral indicators and benchmarks allow us to track the various elements of action that together will allow us to meet the Paris Agreement's global temperature goal as set out in the Paris Agreement. These sectoral benchmarks speak more closely to those making the relevant decisions and help to map out Paris-compatible pathways in more detail.

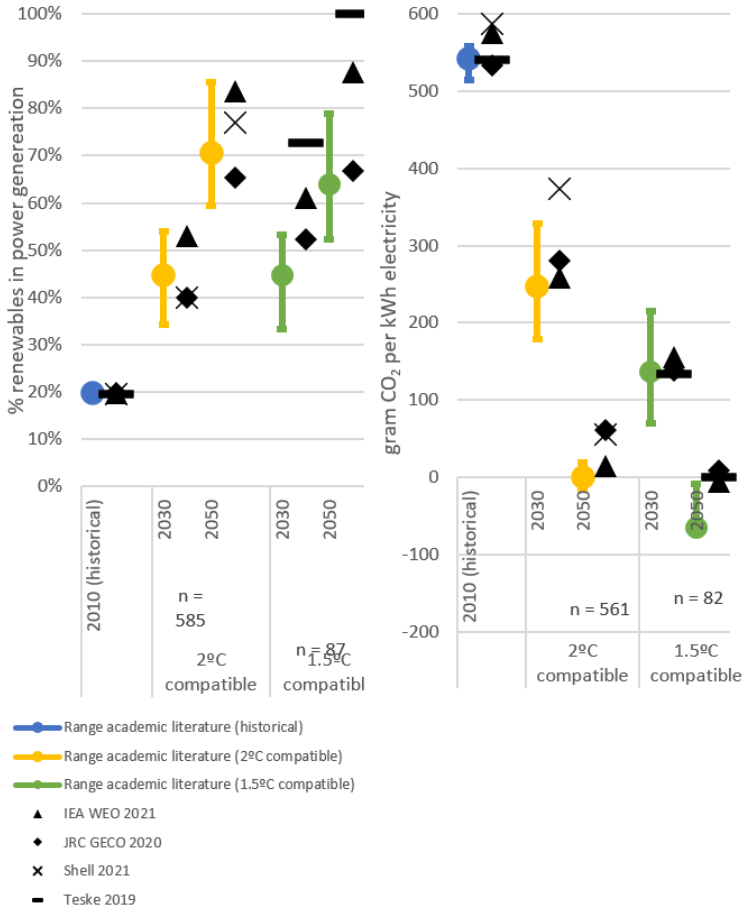
We have defined and analysed a global-level series of Paris-compatible benchmarks, across five major sectors: Power, Transport, Industry, Buildings, and AFOLU. Within each sector, we define benchmarks for several separate but complementary indicators, focusing on both 2030 and 2050, based on information and data derived from the scenario database of the IPCC 6th AR6 Assessment Report (IPCC, 2022). We define detailed Paris-compatible sectoral benchmarks as a level of an indicator that would be "sufficient" for climate action to decarbonise sectors in line with the Paris Agreement's 1.5°C temperature limit. The sectoral benchmarks should be technically and economically feasible within the foreseeable future, considering current circumstances, including social aspects, and should push boundaries on all levels and increase our chances of collectively meeting the Paris temperature limit. These benchmarks should prioritise mitigation options that lead to the deepest and fastest emission reductions, but should also include other options that we are confident are feasible, based on the current development of technologies and the time taken to make changes to existing stock, infrastructure or to scale-up new technologies. These benchmarks can be reached through various decarbonisation routes and mitigation options.

The Power Sector

The electricity sector is at the forefront of the low-carbon transition, demonstrated by the upscaling of renewable energy technologies combined with their rapid cost reductions. In addition, action in the power sector has a high priority as it directly enables the successful decarbonisation of the demand sectors, including heat demands, moving from fossil fuels to clean electricity where possible (e.g. through electric vehicles, heat pumps, electrification of industrial processes etc). Coal phase-out should be the top priority, as coal is by far the most carbon-intensive option to generate electricity. In Paris-compatible scenarios, coal's share in power generation needs to be reduced to (close to) zero by 2030 in developed countries and by 2040 at the very latest in emerging economies where coal currently dominates the electricity supply. In all countries, CO_2 emissions per unit of electricity produced need to be rapidly reduced from about 550 grCO_2/kWh in 2010 to about 150 grCO_2/kWh in 1.5C-compatible scenarios in 2030, and then they should reach zero ideally before 2050, and even turn "negative" in 2050 (see figure below), depending on the availability and emergence of Carbon Dioxide Removal options, in particular BECCS.

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

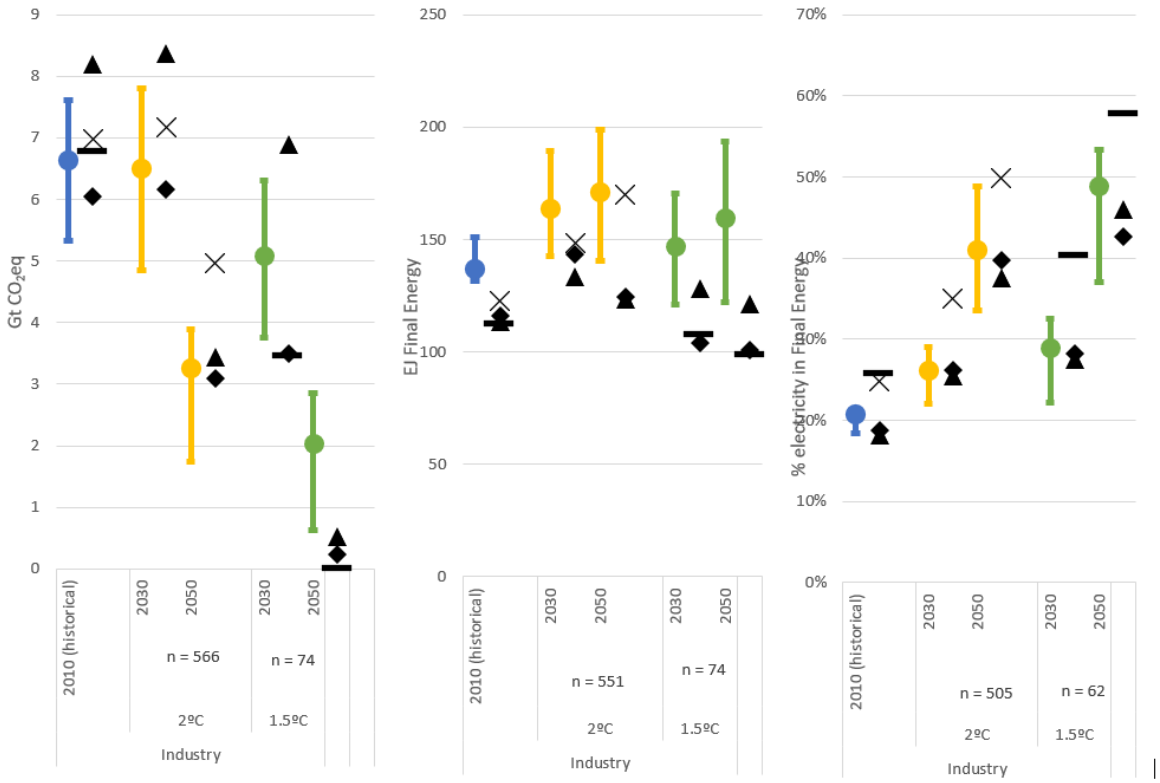
Renewables need to be ramped up at a rapidly accelerated pace to deliver emissions-free electricity before 2050 in Paris-compatible scenarios. The share of renewables in electricity generation should increase from 20% in 2010 to about 50% in 2030 according to Paris-compatible scenarios and further to 70-80% in 2050 according to IPCC scenario results. Other scenarios from international organisations (e.g. IEA) are even more ambitious, projecting renewable energy shares increasing to more than 90% by 2050, especially when other low-emission options (e.g. nuclear, carbon capture and storage (CCS)) face limitations. From all emissions-free options, renewables seem to be the most viable given the rapid reduction in their costs and fast technology developments. Variable renewable energy sources can be backed with storage options, the production of synthetic gas or hydrogen from renewable electricity and its use e.g. in power-reconversion, expansion of electricity grids, end-use flexibility options and smart grid developments. CCS options combined with fossil fuels gain limited shares, because CCS itself is not emissions free and (given current technology cost trends) CCS is already or soon will be uneconomic compared to renewables with storage. The current generation of nuclear power plants is not flexible enough for cost-effective system integration with high shares of renewable energy, while further deployment of nuclear faces serious acceptance and licensing issues as well as cost overruns in several countries worldwide.



NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

The Industry Sector

The industry sector – and especially the energy-intensive manufacturing processes to produce steel, cement, chemicals, paper and pulp – is often considered as the hardest to abate sector, due to limited availability and high costs of low-emission options, while increased energy costs may also raise competitiveness issues leading to trade losses in international markets. Our analysis shows that the key decarbonisation benchmarks are: accelerated efficiency improvements (e.g. heat recovery, using best available technologies, etc.), to ensure compatibility with the 1.5°C goal, emissions from the industry sector should decline by about 27% by 2030 and 70% by 2050 relative to 2010 levels, while reductions can even reach close to 100% in net-zero scenarios from international organisations. Mitigation scenarios also incorporate enhanced material efficiency and large reductions in energy intensity of industrial production, as using less steel or cement can result in further emissions reductions and also allows low-carbon technologies (mostly electricity and hydrogen) to cover higher shares of final energy demand. Electrification of industry needs to increase from about 20% in 2010 to around 30% in 2030 and further to 50% in 1.5C scenarios in 2050. For some industrial processes, electrification provides a key potential route for decarbonisation when accompanied by low-emission electricity. Not all industrial production processes can be electrified, and thus other approaches for decarbonisation should be considered (e.g. hydrogen, CCS/CCU). This heterogeneity of industry actors makes a sector-specific consideration of industry in GST obvious.

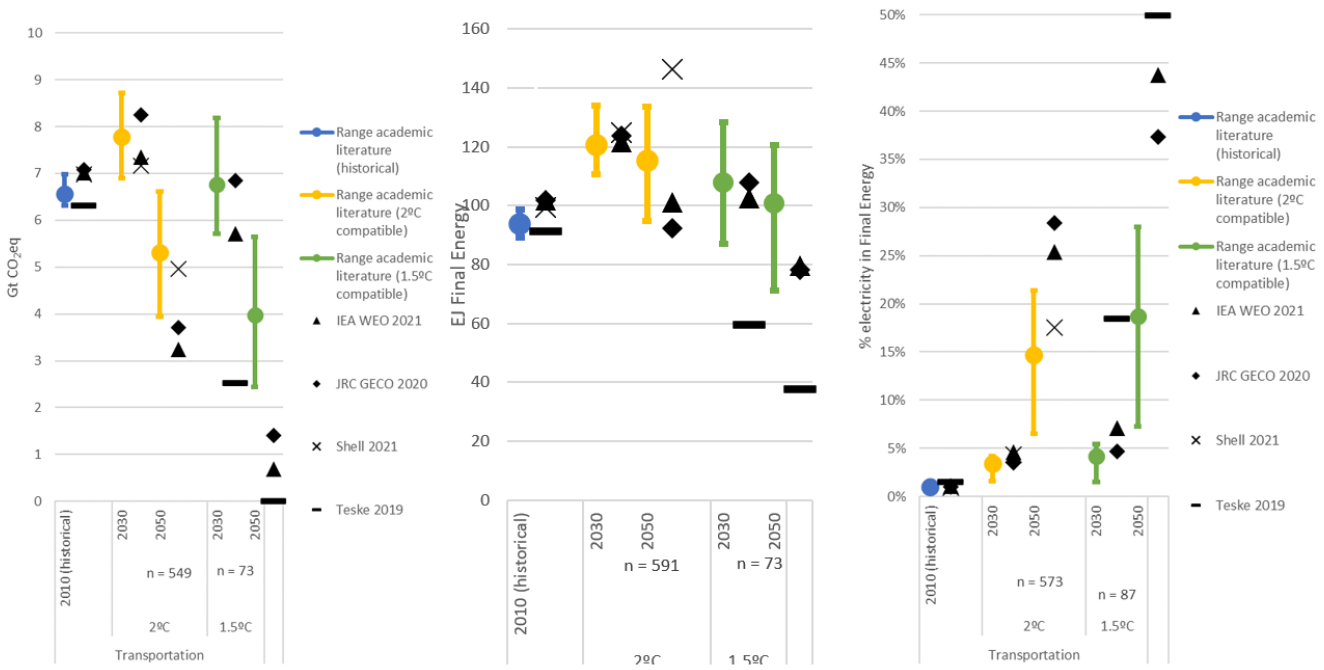


NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

The Transport Sector

In Paris-compatible scenarios, the transport sector is set for a major transformation away from the current oil-dominant paradigm. In contrast to historic trends with rapidly increasing transport-related emissions as a result of rapid motorisation globally, growing mobility activity and transport volumes, and heavy reliance on oil products, Paris-compatible scenarios from the IPCC AR6 show that global transport CO_2 emissions should – after decades of significant growth – decline by about 50% in 1.5°C-compatible scenarios over the 2010-2050 period. Most of the remaining transport-related emissions in 2050 come from the aviation and maritime sectors, which have a limited number of decarbonisation options and face challenges in the upscaling of low-emission fuels. The required emission reduction is even larger and amounts to 90-100% below 2010 levels in net-zero scenarios from international organisations.

Despite rapidly increasing motorisation rates and mobility activity by 2050, final energy demand in Paris-compatible scenarios is projected to increase by only 15% by 2030 and 10% by 2050 from 2010 levels (while even declining in some net-zero scenarios) pointing towards increasing energy efficiency in all vehicles and transportation modes (cars, trucks, ships, planes), combined with the emergence of more efficient energy forms. In particular the share of electricity in the transport sector is set for a rapid increase from the current less than 1% to more than 5% in 2030 and further to 15-30% by 2050, while electricity share is found even larger (close to 50% by 2050) in scenarios from international organisations, as a result of the massive uptake of electric vehicles that reach very high market shares already by 2030 and even more in 2050. The share of sustainable non-fossil fuels (electricity, hydrogen, synthetic fuels) for domestic transport should increase close to 90-100% by 2050 in net-zero scenarios, but given the technological difficulties in achieving full decarbonisation in shipping and aviation, most 2050 benchmarks for the share of low emission fuels in transport do not reach 100%. Overall, decarbonising transportation is heading for a tough time as a reversion of the current emissions trend is mandatory. Mitigation options could be very country specific, which makes a sector-specific consideration in the GST process valuable.

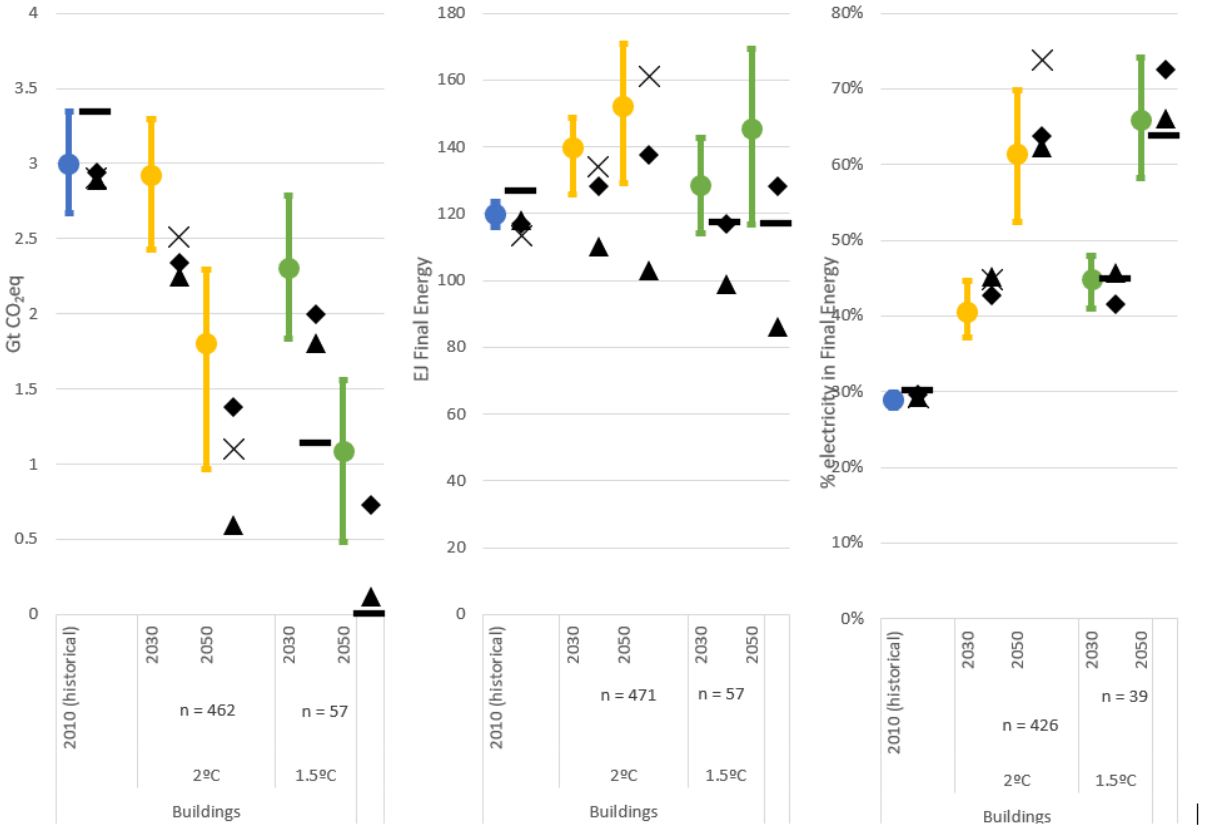


NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

The Buildings Sector

The buildings sector is set for a rapid expansion, especially in developing countries as a result of increasing income, improved living standards and comfort, and population growth. However, to be compatible with the 1.5°C goal, CO_2 emissions from buildings should decline by 25% by 2030 from 2010 levels, while the reduction is even larger in 2050 (about 70%). Recent net-zero scenarios from the IEA suggest even larger reductions of 90-100% by 2050. The main technical emission reduction options in the sector include: 1) accelerated reduction of energy intensity of the building stock (e.g. through renovation and high thermal building standards); 2) a rapid shift to low carbon heating, cooling, and cooking (e.g. heat pumps, district heating/cooling, the direct use of renewable energy); 3) further efficiency improvements of appliances and equipment which are key to keeping energy demand and emissions low while providing adequate living standards. In particular, the share of electricity in buildings' energy consumption is projected to increase rapidly from the current 30% to about 45% in 1.5°C scenarios in 2030 and further to 65-70% in 2050, both accordingly to the IPCC AR6 scenario database and the key international benchmarks studies.

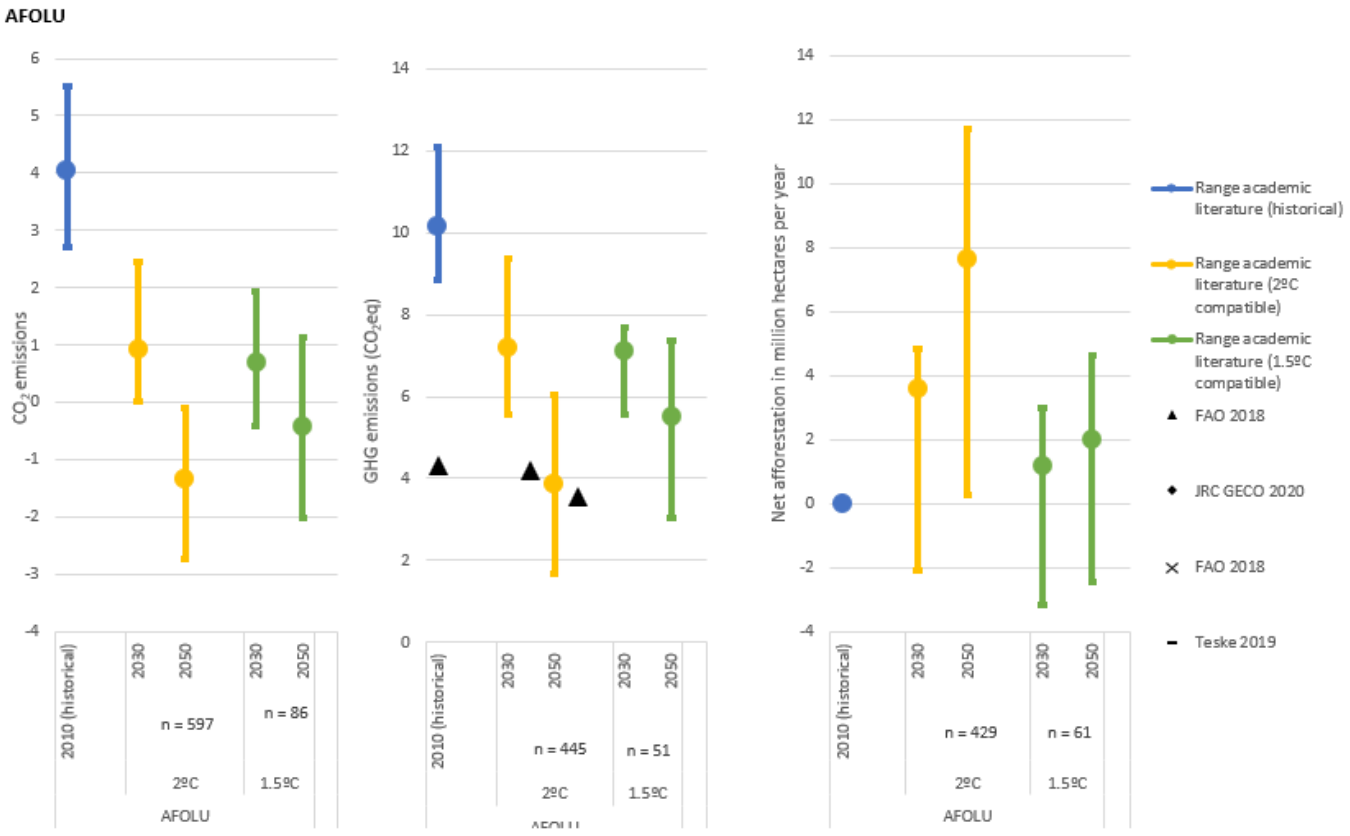
Moreover, embodied energy and emissions in building materials will play an increasingly important role when buildings become more efficient (Ürge-Vorsatz et al., 2020). Embodied emissions can be reduced by using low-carbon materials, re-using building materials, and extending life-time of building components (Churkina et al., 2020). Finally, especially in developed countries demand side measures are required to enable sufficient forms of living and curb growth in per-capita floor space. On the global scale – but also within nations – the building stock is highly diverse, which makes a sector-specific consideration in the GST indispensable.



NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

The AFOLU sector

In the AFOLU sector, the Agriculture (A) sub-sector is a source of GHG emissions, while the Forestry and Other Land Use (FOLU) sub-sector is both a source and a sink of GHGs. The FOLU sub-sector is often considered to have a large potential for mitigation at low cost (Griscom et al., 2017; Roe et al., 2019). Land-based mitigation options received increased attention by IPCC e.g., through the Special Report on Climate Change and Land (IPCC, 2018a), precisely because of its CO_2 removal potential. Our analysis shows that when considering the net emissions and removals of CO_2 and non-CO_2 gases, AFOLU remains a source for 2030 and 2050 for both scenarios due to non-CO_2 emissions. On the other hand, among the options considered net afforestation show a large potential but will require a large amount of land for its deployment in particular for scenarios under 2°C by 2050 of 8 million hectares (ha) per year on average (although with very large uncertainties) and half or it by 2030. Instead, under 1.5°C scenarios the land required for net afforestation is about 2 million ha per year for both 2030 and 2050, showing less reliance on this mitigation measure. Overall, emission measures to reduce methane in agriculture combined with reducing deforestation and increasing forest cover seem to be the most promising options considered. The FOLU sub-sector needs to become a significant net sink by 2050 under both 2°C and 1.5°C scenarios. Although, 1.5°C scenarios rely less on the sub-sector's sink potential compared to the analysed 2°C scenarios. Yet, overall, the AFOLU sector will remain a net emitter by 2030. The complexities of the AFOLU sector are poorly represented in integrated assessment models, and historical and present emissions are still not good enough, although new harmonised datasets are emerging that could be used in coming years to improve predictions and align bottom-up and top-down estimates (Grassi et al., 2022).



NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

Challenges in Determining Sectoral Benchmarks

The main challenge in defining the sectoral benchmarks is that a global temperature goal cannot unambiguously be translated into individual actions at the sectoral level. Different strategies and routes could be used to meet the long-term goal, for instance by assigning more reductions to specific sectors, as long as the overall emissions budget is met (since the overall carbon budget determines the long-term temperature change). However, the degree of freedom is limited, as the available emissions budget is small, especially if we consider the 1.5°C goal. It is clear that all sectors and countries will eventually have to reduce emissions close to net zero. So, if one sector is slower than this global trend, another sector needs to be equivalently faster, or emissions need to be removed from the atmosphere through the upscale of CDR technologies, which however are commercially immature, expensive and face large technical, environmental and societal risks. A good starting point can be to ask whether a sector can decarbonise by 2050, and if not, why? In this situation the differences between sectors disappear in the long run, because all need to reach net zero emissions. Even if the endpoint is the same, the transition dynamics and the speed of transformation can be very different across sectors.

The benchmarks consider the extent to which each sector needs to be decarbonised to be compatible with the Paris Agreement, irrespective of who pays for this transition. The very limited carbon budget - in particular for the 1.5°C goal - does not leave much room for some countries to decarbonise more slowly. As the Paris Agreement requires decarbonisation by mid-century there will be a need for financial transfers and other support between countries (e.g. technology transfer, capacity building), to ensure a fair and just transition. The extent of this support and how it can be achieved is beyond the scope of this analysis. Nevertheless, some aspects of fairness are implicitly considered when determining the benchmarks, especially as these are included in IPCC scenarios, e.g. focus on convergence of efficiencies and shares (e.g. share of renewables, emissions per activity), while end-use activities might be growing much faster in developing economies than in developed countries. However, as the focus is on global benchmarks, the equity issue is not explicitly considered here.

Synthesis

Overall, achieving the objectives of the Paris Agreement requires the world to decarbonise by 2050. Our analysis shows that on average all sectors need to decarbonise by mid-century (or slightly after), albeit at different rates. The electricity sector is relatively advanced and is already making quite some progress towards decarbonising, mostly through the rapid deployment and upscaling of renewable energy (wind and solar PV). The sector should continue to be a government priority, especially in avoiding new infrastructure incompatible with the Paris Agreement, such as coal-fired power plants. Industry, transport, buildings need to advance significantly: these sectors are not yet moving as quickly as is necessary to meet Paris goals, and efforts to meet 2030 benchmarks must significantly ramp up. Accelerated electrification of end-uses in transport, buildings and industries combined with carbon-free power supply is a key strategy to reduce emissions across sectors. The FOLU sub-sector needs to become a significant net sink by 2050 under both 2°C and 1.5°C scenarios. Although, 1.5°C scenarios rely less on the sub-sector's sink potential compared to the analysed 2°C scenarios. Yet, overall, the AFOLU sector will remain a net emitter by 2030. In terms of timing, benchmarks differ between sectors, because they all start from a different baseline. But ultimately, differences between sectors shrink over time and governments must pursue all options in all sectors, and sometimes this will require international support between countries. The sectoral benchmarks are useful tools to assess and monitor the progress of national policies and NDCs towards meeting the Paris goals. Policymakers and public authorities can use the benchmarks to assess the adequacy of policy interventions with

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

respect to the Paris Agreement. Our benchmarks provide a guide as to the scale of change that needs to happen, and where - and when, leaving governments the freedom to meet them through different decarbonisation strategies. Finally, our analysis shows that progress by 2030 is important, as decarbonisation by 2050 alone is not sufficient; to keep the ambitious carbon budgets – and associated temperature targets – within reach, progress must ramp up well before 2030 pointing towards the need for revising and significantly enhancing the ambition of NDCs, while stronger and more reliable policies should be put in place to allow achieving these enhanced NDCs and long-term low-emission development strategies.

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

NDC ASPECTS

SUBMISSION TO THE **GLOBAL STOCKTAKE**

Ensuring an Effective Global Stocktake with a Sectoral Perspective

Authors and Contributors

Lukas Hermwille (correspondence: lukas.hermwille@wupperinst.org), Wolfgang Obergassel, Anna Pérez Català, Panagiotis Fragkos, Dirk-Jan Van de Ven, María José Sanz, Marta Torres Gunfaus, Yann Briand, Harro van Asselt, Sebastian Oberthür, Stefan Kronshage, Patrick Jochem, Chun Xia-Bauer.

PARTICIPANTS

NDC ASPECTS has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

Imprint:
Wuppertal Institut für Klima, Umwelt, Energie gGmbH
Döppersberg 19 | 42103 Wuppertal | www.wupperinst.org