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Discussion paper

Transformative mitigation actions as an outcome of the Global Stocktake

by:

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Abstract: Transformative mitigation actions as an outcome of the Global Stocktake

Current actions to mitigate climate change are highly insufficient to keep the temperature goal of the Paris Agreement within reach. It will be key for the Global Stocktake under the Paris Agreement to formulate clear messages on increasing mitigation action. These messages should be concise, name specific actions and targets, and inform Parties in updating and enhancing their actions.

Key mitigation actions are suggested to cover renewable energy, energy efficiency and sufficiency, the phasing out of fossil fuels and related subsidies, actions in transport, buildings and industry, circular material flows, the reduction of methane emissions, actions in the land sector and sustainable food systems.

The proposed mitigation actions and targets could be included as key messages in the cover decision of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA). Targets could also be included in declarations as part of the Global Stocktake outputs. Finally, additional information on key mitigation actions could be provided in a technical annex. The messages on mitigation need to address both the time horizon until 2030 to avert catastrophic climate change and the time horizon until 2035 for new NDCs.

Kurzbeschreibung: Transformative Minderungsmaßnahmen als Ergebnis der globalen Bestandsaufnahme

Die derzeitigen Maßnahmen zur Eindämmung des Klimawandels reichen bei weitem nicht aus, um das Temperaturziel des Übereinkommens von Paris in Reichweite zu halten. Für die Globale Bestandsaufnahme im Rahmen des Übereinkommens von Paris wird es von entscheidender Bedeutung sein, klare Botschaften zur Verstärkung von Minderungsanstrengungen zu formulieren. Diese Botschaften sollten prägnant sein, spezifische Maßnahmen und Ziele benennen und die Vertragsparteien bei der Aktualisierung und Erweiterung ihrer Maßnahmen unterstützen.

Es wird vorgeschlagen, dass die wichtigsten Minderungsmaßnahmen erneuerbare Energien, Energieeffizienz und -suffizienz, den Ausstieg aus fossilen Brennstoffen und den damit verbundenen Subventionen, Maßnahmen in den Bereichen Verkehr, Gebäude und Industrie, Kreislaufwirtschaft, die Verringerung von Methanemissionen, Maßnahmen im Landsektor und nachhaltige Ernährungssysteme umfassen.

Die vorgeschlagenen Minderungsmaßnahmen und -ziele könnten als Schlüsselbotschaften in die Mantelentscheidung der Konferenz der Vertragsparteien aufgenommen werden, die als Tagung der Vertragsparteien des Übereinkommens von Paris (CMA) dient. Ziele könnten auch in Erklärungen als Teil der Ergebnisse der globalen Bestandsaufnahme aufgenommen werden. Schließlich könnten in einem technischen Anhang zusätzliche Informationen über wichtige Minderungsmaßnahmen bereitgestellt werden. Die Botschaften zur Minderung müssen sich sowohl auf den Zeithorizont bis 2030 zur Abwendung eines katastrophalen Klimawandels als auch auf den Zeithorizont bis 2035 für neue NDCs beziehen.

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List of abbreviations

CH₄	Methane
CMA	Conference of the Parties serving as the meeting of the Parties to the Paris Agreement
COP	Conference of the Parties
CO₂	Carbon dioxide
CO₂eq	Carbon dioxide equivalent
F-gases	Fluorinated gases
GHG	Greenhouse Gas
Gt	Gigatonne
HFC	Hydrofluorocarbon
IPCC	Intergovernmental Panel on Climate Change
N₂O	Nitrous oxide
NDC	Nationally Determined Contribution
t	tonne
TW	Terawatt
USD	United States Dollar

Summary

The aim of the Global Stocktake under the Paris Agreement is to assess the collective progress of Parties towards achieving the purpose of the Agreement and its long-term goals. The outputs of the Global Stocktake are key in informing Parties in updating and enhancing their actions and support, as well as in enhancing international cooperation for climate action.

In the thematic area of mitigation, the actions which have been implemented and put forward by Parties in their Nationally Determined Contributions (NDCs) are collectively highly insufficient to keep the temperature goal of the Paris Agreement within reach. Hence, it will be key for the Global Stocktake to formulate clear messages on increasing mitigation actions. These messages should be concise, name key actions and targets, and inform Parties in updating and enhancing their actions.

The cover decisions of the climate change conferences in 2021 and 2022 already contained some specific language on increasing action and support. In the area of mitigation, these cover decisions addressed, inter alia, collective progress, the need for accelerated action, energy systems, non-CO₂ emissions and ecosystems. The outputs of the Global Stocktake should go beyond the language of previous years and contain additional actions and sectors.

Based on available literature on mitigation actions and their potential, the following key mitigation actions are suggested to be included in the outputs of the Global Stocktake:

- ▶ Boost wind and solar electricity supply
- ▶ Increase energy efficiency and sufficiency
- ▶ Phase out fossil fuels
- ▶ Phase out fossil fuel subsidies while enabling a just transition
- ▶ Electrify the vehicle fleet and facilitate a shift in transportation modes
- ▶ Improve efficiency and shift towards renewable energy in the buildings sector
- ▶ Decarbonize industrial production
- ▶ Circular material flows
- ▶ Reduce methane emissions from fossil fuels, agriculture and waste
- ▶ Stop deforestation and maximise removals on land
- ▶ Sustainable food systems

These mitigation actions should be complemented by specific targets, both quantitative and qualitative. Depending on national circumstances, Parties may decide not to pursue all mitigation actions, and they may take additional actions. When implementing these mitigation actions, their social and economic consequences and impacts need to be taken into account and negative impacts minimised.

The proposed mitigation actions and targets could be included as key messages in the cover decision of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA). Targets could also be included in declarations as part of the Global Stocktake outputs. Finally, additional information on key mitigation actions could be provided in a technical annex. The messages on mitigation need to address both the time horizon until 2030 and the

time horizon of new NDCs, which is 2035, keeping in mind the findings of the Intergovernmental Panel on Climate Change (IPCC) that greenhouse gas emissions need to be reduced by 43% and 60% compared to 2019 by 2030 and 2035, respectively.

The Global Stocktake should also provide guidance for Parties on how to incorporate its outputs into their next NDCs. Parties will need to assess the feasibility of actions, consider additional actions and assess impacts, barriers and enablers. As targets, rather than actions, constitute the key information in NDCs, Parties should in a next step set such targets. These should be achievable with the selected actions and in line with the long-term goals of the Paris Agreement. In a next step, Parties should plan their mitigation actions, ensure that they are aligned with long-term strategies and goals, and address finance flows and international cooperation. Finally, Parties should update their current NDCs with updated targets, communicate new NDCs with new targets and implement the mitigation actions.

When Parties report on progress in implementing and achieving their NDCs, they could include indicators for the various key targets. This would help tracking the collective progress towards these targets.

Zusammenfassung

Das Ziel der Globalen Bestandsaufnahme im Rahmen des Übereinkommens von Paris ist es, den kollektiven Fortschritt der Vertragsparteien bei der Erreichung des Zwecks des Übereinkommens und seiner langfristigen Ziele zu beurteilen. Die Ergebnisse der Globalen Bestandsaufnahme sind von entscheidender Bedeutung für die Information der Vertragsparteien bei der Aktualisierung und Erweiterung ihrer Maßnahmen und Unterstützung sowie für die Verbesserung der internationalen Zusammenarbeit im Klimaschutz.

Im Themenbereich Minderung sind die von den Vertragsparteien in ihren national festgelegten Beiträgen (nationally determined contributions – NDC) vorgeschlagenen und umgesetzten Maßnahmen in der Summe völlig unzureichend, um das Temperaturziel des Übereinkommens von Paris in Reichweite zu halten. Daher wird es für die globale Bestandsaufnahme von entscheidender Bedeutung sein, klare Botschaften zur Verstärkung der Minderungsmaßnahmen zu formulieren. Diese Botschaften sollten präzise sein, die wichtigsten Maßnahmen und Ziele benennen und die Vertragsparteien bei der Aktualisierung und Erweiterung ihrer Maßnahmen unterstützen.

Die Mantelentscheidungen der Klimakonferenzen 2021 und 2022 enthalten bereits einige spezifische Formulierungen zur Erweiterung von Maßnahmen und Unterstützung. Im Bereich Minderung betrafen diese Beschlüsse unter anderem den kollektiven Fortschritt, die Notwendigkeit beschleunigter Maßnahmen, Energiesysteme, Nicht-CO₂-Emissionen sowie Ökosysteme. Die Ergebnisse der globalen Bestandsaufnahme sollten über die Sprache der vergangenen Jahre hinausgehen und zusätzliche Maßnahmen und Sektoren umfassen.

Auf der Grundlage der verfügbaren Literatur über Minderungsmaßnahmen und deren Potenzial werden die folgenden zentralen Maßnahmen vorgeschlagen, die in die Ergebnisse der globalen Bestandsaufnahme aufgenommen werden sollten:

- ▶ Ausbau der Wind- und Solarstromerzeugung
- ▶ Steigerung der Energieeffizienz und -suffizienz
- ▶ Ausstieg aus fossilen Brennstoffen
- ▶ Ausstieg aus Subventionen für fossile Brennstoffe, wobei ein gerechter Übergang ermöglicht wird
- ▶ Elektrifizierung der Fahrzeugflotte und Verlagerung von Verkehrsträgern
- ▶ Verbesserung der Effizienz und Umstellung auf erneuerbare Energien im Gebäudesektor
- ▶ Dekarbonisierung der industriellen Produktion
- ▶ Zirkuläre Stoffströme
- ▶ Verringerung der Methanemissionen aus fossilen Brennstoffen, Landwirtschaft und Abfall
- ▶ Stopp der Entwaldung und Maximierung von Senken im Landsektor
- ▶ Nachhaltige Lebensmittelsysteme

Diese Minderungsmaßnahmen sollten durch spezifische quantitative und qualitative Ziele ergänzt werden. Je nach den nationalen Gegebenheiten können die Vertragsparteien beschließen,

nicht alle Minderungsmaßnahmen durchzuführen, und sie können zusätzliche Maßnahmen ergreifen. Bei der Umsetzung dieser Minderungsmaßnahmen müssen deren soziale und wirtschaftliche Folgen und Auswirkungen berücksichtigt und negative Auswirkungen minimiert werden.

Die vorgeschlagenen Minderungsmaßnahmen und Ziele könnten als Schlüsselbotschaften in die Mantelentscheidung der Konferenz der Vertragsparteien aufgenommen werden, die als Tagung der Vertragsparteien des Pariser Abkommens dient (Conference of the Parties serving as the meeting of the Parties to the Paris Agreement – CMA). Die Ziele könnten auch in Erklärungen als Teil der Ergebnisse der globalen Bestandsaufnahme aufgenommen werden. Schließlich könnten in einem technischen Anhang zusätzliche Informationen über wichtige Minderungsmaßnahmen bereitgestellt werden. Die Botschaften zur Minderung müssen sowohl den Zeithorizont bis 2030 als auch den Zeithorizont der neuen NDCs, d. h. 2035, berücksichtigen. Dabei sind die Ergebnisse des Zwischenstaatlichen Ausschusses für Klimaänderungen (Intergovernmental Panel on Climate Change – IPCC) zu berücksichtigen, wonach die Treibhausgasemissionen bis 2030 um 43 % und bis 2035 um 60 % im Vergleich zu 2019 reduziert werden müssen.

Die globale Bestandsaufnahme sollte den Vertragsparteien auch Anhaltspunkte dafür liefern, wie sie die Ergebnisse in ihre nächsten NDCs einbeziehen können. Die Vertragsparteien müssen die Durchführbarkeit von Maßnahmen bewerten, zusätzliche Maßnahmen in Erwägung ziehen und die Auswirkungen sowie hemmende und unterstützende Faktoren bewerten. Da Ziele und nicht Maßnahmen die wichtigsten Informationen in den NDCs darstellen, sollten die Vertragsparteien in einem nächsten Schritt solche Ziele festlegen. Diese sollten mit den ausgewählten Maßnahmen erreichbar sein und im Einklang mit den langfristigen Zielen des Übereinkommens von Paris stehen. In einem nächsten Schritt sollten die Vertragsparteien ihre Minderungsmaßnahmen planen, sicherstellen, dass sie mit langfristigen Strategien und Zielen in Einklang stehen, sowie Finanzströme und internationale Zusammenarbeit berücksichtigen. Schließlich sollten die Vertragsparteien ihre derzeitigen NDCs mit neuen Zielen aktualisieren, neue NDCs mit neuen Zielen übermitteln und die Minderungsmaßnahmen umsetzen.

Wenn die Vertragsparteien über die Fortschritte bei der Umsetzung und Erreichung ihrer NDCs berichten, könnten sie Indikatoren für die verschiedenen Schlüsselziele angeben. Dies würde dazu beitragen, den kollektiven Fortschritt in Richtung dieser Ziele zu verfolgen.

Introduction

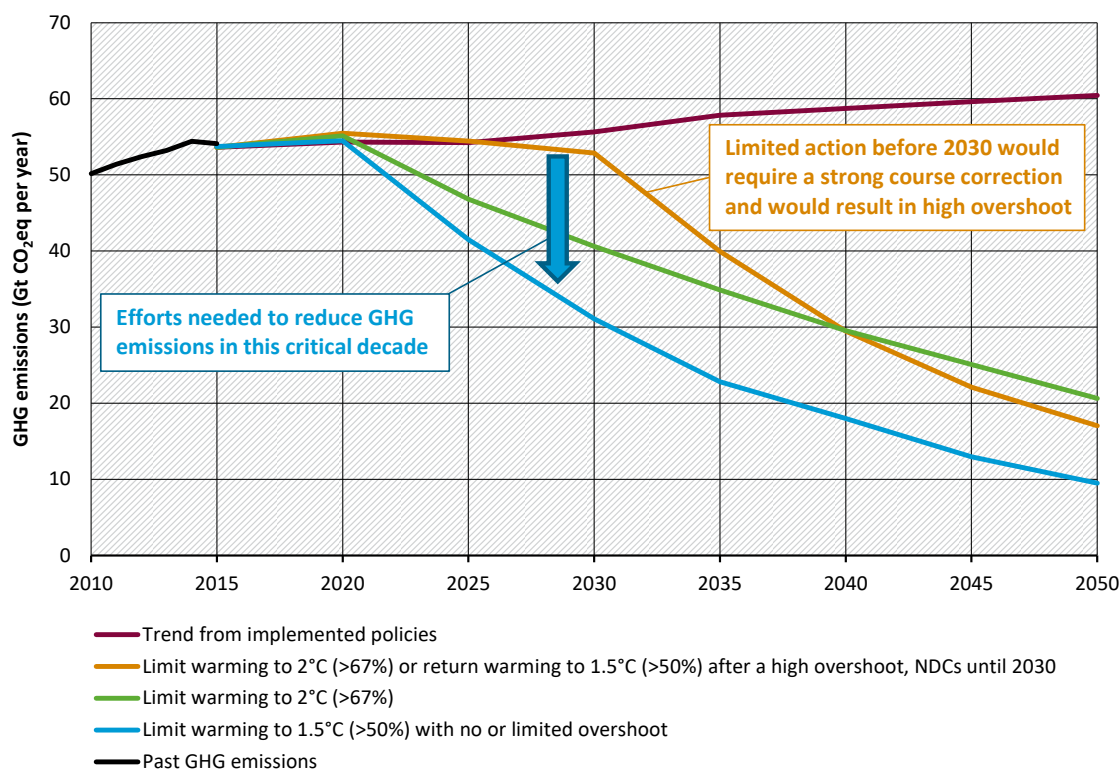
During the Global Stocktake under the Paris Agreement, Parties assess their collective progress towards achieving the purpose of the Agreement and its long-term goals. The outcome of the Global Stocktake shall inform Parties in updating and enhancing their actions and support, as well as in enhancing international cooperation for climate action (UNFCCC 2015b, Article 14).

Role of mitigation in the Global Stocktake

The Global Stocktake addresses three thematic areas, which are related to the long-term goals of the Paris Agreement, namely mitigation; adaptation; and means of implementation and support. In addition, the Global Stocktake takes into account efforts that address the social and economic consequences and impacts of response measures; and efforts that avert, minimize and address loss and damage associated with the adverse effects of climate change (UNFCCC 2018a, paragraph 6).

In this paper, we focus on the thematic area of mitigation. A wide range of opportunities for action exists, and many Parties and non-Party stakeholders have implemented effective actions to reduce greenhouse gas (GHG) emissions. However, what has been implemented so far and has been put forward by Parties in their current Nationally Determined Contributions (NDCs) is highly insufficient to keep the temperature goal of the Paris Agreement within reach. The implementation of current NDCs would result in a temperature increase of approximately 2.5°C by the end of this century (UNEP 2022). Figure 1 illustrates the importance of reducing GHG emissions in the coming years. If GHG emissions cannot be reduced substantially by 2030, the temperature goal of the Paris Agreement can be achieved with a high temperature overshoot only.

Figure 1: Global GHG emissions of modelled pathways, and projected emissions



Source: Own illustration, Öko-Institut, based on data from Kriegler et al. (2022), Data for Figure SPM.4 – Summary for Policymakers of the Working Group III Contribution to the IPCC Sixth Assessment Report, <https://ipcc-browser.ipcc-data.org/browser/dataset?id=3878>

The thematic area of mitigation cannot be seen on isolation. As an example, mitigation actions have various social and economic consequences, in particular in economies which are centred around fossil fuels. Such mitigation actions have to be implemented in a way that allows for a just transition to a low GHG emissions economy. In addition, there is an urgent need for effective mitigation actions because the options for adaptation and for avoiding/minimising loss and damage become limited with increasing temperatures (IPCC 2023).

Outputs of the Global Stocktake

After the finalisation of the technical phase of the Global Stocktake in June 2023, preparations are underway for the ‘consideration of outputs’ phase, which will be completed during the climate change conference in Dubai in November/December 2023.

The outputs of the Global Stocktake, which are to be elaborated during that conference, shall identify opportunities/challenges in enhancing action and support in relation to the thematic areas of the global stocktake. They shall also summarise key political messages for strengthening action and enhancing support. These outputs shall be referenced in a decision by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA) and/or a declaration (UNFCCC 2018a, paragraph 34).

Preparing Nationally Determined Contributions

The outputs of the Global Stocktake will be central in informing Parties in preparing new NDCs, which set out their efforts to achieve the purpose of the Paris Agreement. While the targets contained in each NDC are self-determined by the respective Party, it can be expected that Parties will consider the opportunities and messages which emerge from the Global Stocktake when selecting actions to be included in their NDCs. This is because Parties are required to provide information in their NDC on ‘how the Party’s preparation of its nationally determined contribution has been informed by the outcomes of the Global Stocktake’ (UNFCCC 2018b, Annex I, paragraph 4). If the outputs of the Global Stocktake contain specific targets, Parties could include them in their NDCs. If the outputs focus on proposed actions rather than targets, Parties could formulate targets which can be achieved by implementing the proposed actions.

While NDCs are not limited to mitigation, the mitigation of climate change plays a central role in NDCs. According to Article 4 of the Paris Agreement, Parties shall pursue domestic mitigation measures, and each Party shall communicate an NDC every five years. The next NDCs are due in 2025 (UNFCCC 2015a, paragraphs 23 and 24), and Parties are encouraged to communicate in that year an NDC with an end date of 2035 (UNFCCC 2021b, paragraph 2).

Given the urgency of responding to climate change, the Global Stocktake should not only inform actions on a time scale up to 2035, but it should also facilitate the scaling-up of short-term action. At the climate change conference in November 2022, the CMA recognised that limiting global warming to 1.5 °C requires rapid, deep and sustained reductions in global GHG emissions of 43 % by 2030 relative to the 2019 level, and that this requires accelerated action in this critical decade (UNFCCC 2022, paragraphs 13 and 15).

Messages on mitigation in the outputs of the Global Stocktake

To support the political phase of the Global Stocktake in generating momentum and formulating clear messages on the action required, it is important to have a clear picture of the available mitigation options and how they can be scaled up, in order to facilitate transformative change.

In this paper, we discuss messages on mitigation which could be included in the outputs of the Global Stocktake. We use elements from earlier CMA decisions as a starting point and discuss which additional elements could be included. We also present selected mitigation actions which

have a high mitigation potential and could help Parties and non-Party stakeholders in cutting GHG emissions and increasing GHG removals by sinks. While the applicability and effectiveness of mitigation actions strongly depends on national circumstances, the promotion of specific mitigation actions during the political phase of the Global Stocktake could guide Parties and non-Party stakeholders in setting priorities for increased action.

Aim and structure of this discussion paper

The aim of this discussion paper is to provide an overview of key mitigation actions which are particularly relevant in the context of the Global Stocktake. For each of these actions, more detailed information is available in specialised literature, and several compilations of mitigation actions are also available (e.g. IPCC 2022a, IEA 2022a, UNEP 2022, Boehm et al. 2022).

Chapter 1 of this paper discusses possible outputs of the Global Stocktake, and how they could address mitigation. As a background for possible messages on mitigation, those messages which can already be found in earlier CMA decisions are presented in chapter 2. Using these messages as a starting point, chapter 3 suggests key actions and targets which could be included in the outputs of the Global Stocktake. Chapter 4 discusses options for including these actions and targets in the outputs, and it outlines how additional mitigation actions could be incorporated into current and new NDCs.

1 Outputs of the Global Stocktake

The elements of the consideration of outputs component of the Global Stocktake are under discussion by the joint contact group on the Global Stocktake (UNFCCC 2023b). It can be expected that the outputs to be agreed in December 2023 will include a CMA decision, and they may also include additional elements such as declarations or a technical annex with more detailed information (UNFCCC 2023c; 2023d).

Indicative draft structure of a CMA decision

An indicative draft structure of a CMA decision on the Global Stocktake was compiled during the session of the subsidiary bodies in Bonn in June 2023 (UNFCCC 2023a). This indicative draft structure contains the following elements:

- A. Preamble
- B. Context and cross-cutting considerations
- C. Collective progress [...]; and informing Parties in updating and enhancing, in a nationally determined manner, action and support
- D. Enhancing international cooperation for climate action
- E. Guidance and way forward

Section C is further divided into the thematic areas and topics discussed during the Global Stocktake, i.e. mitigation; adaptation; finance flows and means of implementation and support (with different options for structuring these issues); efforts related to loss and damage; and efforts related to response measures.

Other outputs of the Global Stocktake

In addition to a CMA decision, the following outputs of the Global Stocktake have been suggested (UNFCCC 2023c):

- ▶ one or several political declarations, which could convey high-level political messages both to Parties and non-Party stakeholders; and
- ▶ a technical annex, which could include a menu of options to advance and scale up climate action, and which could also include the summary reports of the technical dialogue meetings.

Addressing mitigation in the outputs of the Global Stocktake

No matter which elements will constitute the outputs of the Global Stocktake, it will be important to include key messages which set the course for Parties and non-Party stakeholders in pursuing ambitious action. This applies to all thematic areas of the Global Stocktake. As we focus on the thematic area of mitigation in this paper, we propose the following criteria which such messages should fulfil in the area of mitigation.

- ▶ The messages have to be concise. Specifically for the thematic area of mitigation, they could highlight some key actions which can be expected to have transformative/high mitigation impacts.
- ▶ The messages have to name clear targets. Ideally, they will include quantitative targets such as, for example, shares of renewable energy. In case Parties cannot agree on quantitative targets in the CMA decision text, such targets could still be spelled out in declarations, which Parties and non-Party stakeholders could subscribe to.

- ▶ The messages have to inform Parties in updating and enhancing their action and support. For the thematic area of mitigation, they could specify whether the actions should focus on the current decade up to 2030 and hence be included in updated NDCs and/or whether they should be a focus of the next NDCs, which have a longer timeline up to 2035.

Besides such key messages, more detailed information could be provided in a technical annex. In the area of mitigation, such an annex could provide information on specific mitigation actions, including, for example, targets, indicators, and enabling conditions. The summary reports of the technical dialogue (Winkler and Akhtar 2022; 2023a; 2023b) provide a useful source of information for such a technical annex.

2 Key messages on mitigation in earlier CMA cover decisions

The Global Stocktake is not the first instance when key messages on increasing climate ambition are deliberated by the CMA. In earlier years, the cover decisions of climate change conferences already contained language on increasing action and support. In particular, the cover decisions of the climate change conferences in Glasgow (1/CMA.3, UNFCCC 2021a) and Sharm El-Sheikh (1/CMA.4, UNFCCC 2022) included key messages on several topics which are of interest to the Global Stocktake. Table 1 provides an overview of such messages relating to mitigation. Similarly, messages relating to adaptation, loss and damage, and support are included in these cover decisions. However, the messages on these other thematic areas are not summarised here.

Table 1: Overview of topics related to mitigation, which are included in recent CMA cover decisions

Topic	Decision 1/CMA.3 (2021)	Decision 1/CMA.4 (2022)
Collective progress	25. Notes with serious concern the findings of the synthesis report on nationally determined contributions under the Paris Agreement[...]	20. Notes with serious concern the finding in the latest synthesis report on nationally determined contributions [...]
Need for accelerated action	23. Also recognizes that this requires accelerated action in this critical decade [...] 26. Emphasizes the urgent need for Parties to increase their efforts to collectively reduce emissions through accelerated action and implementation of domestic mitigation measures [...]	16. Also recognizes that this requires accelerated action in this critical decade [...] 21. Emphasizes the urgent need for Parties to increase their efforts to collectively reduce emissions through accelerated action and implementation of domestic mitigation measures [...]
Need to align NDCs with long-term strategies	35. Notes the importance of aligning nationally determined contributions with long-term low greenhouse gas emission development strategies ;	
Energy systems	36. Calls upon Parties to accelerate the development, deployment and dissemination of technologies, and the adoption of policies, to transition towards low-emission energy systems , including by rapidly scaling up the deployment of clean power generation and energy efficiency measures, including accelerating efforts towards the phasedown of unabated coal power and phase-out of inefficient fossil fuel subsidies , while providing targeted support to the poorest and most vulnerable in line with national circumstances and recognizing the need for support towards a just transition;	12. Emphasizes the urgent need for immediate, deep, rapid and sustained reductions in global greenhouse gas emissions by Parties across all applicable sectors, including through increasing the use of low-emission and renewable energy , just energy transition partnerships and other cooperative actions; 13. Recognizes that the unprecedented global energy crisis underlines the urgency to rapidly transform energy systems to be more secure, reliable and resilient, including by accelerating clean and just transitions to renewable energy during this critical decade of action; 14. Stresses the importance of enhancing a clean energy mix , including low-emission and renewable energy, at all levels as part of diversifying energy mixes and systems, in line with national circumstances and recognizing the need for support towards just transitions;

Topic	Decision 1/CMA.3 (2021)	Decision 1/CMA.4 (2022)
		28. Calls upon Parties to accelerate the development, deployment and dissemination of technologies, and the adoption of policies, to transition towards low-emission energy systems , including by rapidly scaling up the deployment of clean power generation and energy efficiency measures, including accelerating efforts towards the phasedown of unabated coal power and phase-out of inefficient fossil fuel subsidies , while providing targeted support to the poorest and most vulnerable in line with national circumstances and recognizing the need for support towards a just transition;
Non-CO ₂ emissions	37. Invites Parties to consider further actions to reduce by 2030 non-carbon dioxide greenhouse gas emissions, including methane ;	29. Reiterates its invitation to Parties to consider further actions to reduce by 2030 non-carbon dioxide greenhouse gas emissions, including methane ;
Ecosystems	38. Emphasizes the importance of protecting, conserving and restoring nature and ecosystems to achieve the Paris Agreement temperature goal, including through forests and other terrestrial and marine ecosystems acting as sinks and reservoirs of greenhouse gases and by protecting biodiversity, while ensuring social and environmental safeguards;	30. Emphasizes the importance of protecting, conserving and restoring nature and ecosystems to achieve the Paris Agreement temperature goal, including through forests and other terrestrial and marine ecosystems acting as sinks and reservoirs of greenhouse gases and by protecting biodiversity, while ensuring social and environmental safeguards;
Impacts of implementation, just transition	84. Recognizes the need to take into consideration the concerns of Parties with economies most affected by the impacts of response measures , particularly developing country Parties 85. Also recognizes the need to ensure just transitions that promote sustainable development and eradication of poverty, and the creation of decent work and quality jobs , including through making financial flows consistent with a pathway towards low greenhouse gas emission and climate-resilient development, including through deployment and transfer of technology, and provision of support to developing country Parties;	31. Recognizes the importance of maximizing the positive and minimizing the negative economic and social impacts of the implementation of response measures [...] 50. Affirms that sustainable and just solutions to the climate crisis must be founded on meaningful and effective social dialogue and participation of all stakeholders and notes that the global transition to low emissions provides opportunities and challenges for sustainable economic development and poverty eradication; 51. Emphasizes that just and equitable transition encompasses pathways that include energy, socioeconomic, workforce and other dimensions , all of which must be based on nationally defined development priorities and include social protection so as to mitigate potential impacts associated with the transition, and highlights the important role of the instruments related to social solidarity and protection in mitigating the impacts of applied measures;

Sources: Own compilation of elements included in UNFCCC (2021a) and UNFCCC (2022). Bold font was added by authors to highlight selected key elements.

It can be seen in Table 1 that the CMA decisions of Glasgow (2021) and Sharm El-Sheikh (2022) address a wide range of mitigation-related topics, and they include calls for enhanced action in several sectors. The decision of Sharm El-Sheikh went beyond the previous year's decision in particular in the area of energy systems. It also contained additional messages on the impacts of the implementation of mitigation actions, and on just transition.

While these previous CMA decisions addressed some GHG emission sources, they did not address other important sectors, such as transport, industry or agriculture. For the outputs of the Global Stocktake to be comprehensive in the area of mitigation, additional sectors and actions should be addressed as well.

3 Key messages on mitigation in the outputs of the Global Stocktake

Due to the urgent need for more climate action and the important role of the Global Stocktake in facilitating such action, the statements made in Glasgow (2021) and Sharm El-Sheikh (2022) should be regarded as a floor. In light of the findings of the IPCC (2023), the messages to be agreed as an output of the Global Stocktake in 2023 need to go beyond these earlier statements.

Possible areas of increased action were discussed during the technical dialogue under the Global Stocktake. In particular, mitigation actions in various sectors were addressed during the second session of the technical dialogue. They are summarised in the co-facilitators' summary report of this session (Winkler and Akhtar 2023a, paragraphs 42 to 51).

3.1 Elements for the outputs of the Global Stocktake

The following elements relating to mitigation, which were not included in earlier CMA decisions, could be considered in the Global Stocktake output, such as a CMA decision and/or declaration:

- ▶ **More specific wording on energy systems:** The decisions of Glasgow and Sharm El-Sheikh address the transition towards low-emission energy systems and the rapid scaling-up of clean power generation and energy efficiency. The outputs of the Global Stocktake present an opportunity to be more specific in this wording to spur additional action. They should separately address the following aspects of a clear energy transition:

- The scaling-up of renewable electricity generation
- The phase-out of fossil fuels
- The phase-out of fossil fuel subsidies
- The increase in energy efficiency

For these aspects, specific targets could be formulated. Such targets have been suggested by various organisations (e.g., Boehm et al. 2022, Climate Analytics 2023, C2ES 2023), and the COP28 President-Designate suggested quantitative targets for global renewable energy capacity and energy efficiency in his vision for COP28 (Al Jaber 2023).

- ▶ **More specific wording on non-CO₂ emissions:** Specifically for methane emissions, quantitative targets for the energy sector could be included, and emissions from the agriculture and waste sectors could also be addressed. More than 100 countries already agreed to take voluntary actions to contribute to a collective effort to reduce global methane emissions by at least 30 percent from 2020 levels by 2030 under the Global Methane Pledge¹, and Al Jaber (2023) suggested a quantitative target for oil and gas industry emissions.
- ▶ **Addressing the transport sector:** The transport sector is a key source of GHG emissions globally, and various effective mitigation options are available. Hence, it is important for the outputs of the Global Stocktake to address this sector. As an example, it could include targets for the deployment of electric vehicles or a phase-out of internal combustion engines in new

¹ Global Methane Pledge, <https://www.globalmethanepledge.org/>

vehicles (CZES 2023), and it could call for the scaling-up of zero carbon public transport systems. The Global Stocktake should also point out the need to reduce GHG emissions from aviation and shipping, both domestically and internationally.

- ▶ **Addressing the buildings sector:** The construction, heating and cooling of buildings is a major source of GHG emissions. It is important for the outputs of the Global Stocktake to contain targets for the construction and operation of buildings. As an example, the ‘2030 breakthrough on the built environment’ contains targets for the operation and for embodied carbon in new buildings². Parties could also agree to phase out all support for fossil heating and aim for a full phase-out of fossil heating by a certain date (Obergassel et al. 2023).
- ▶ **Addressing other sectors which are key in contributing to a decarbonization of the economy:** These include:
 - **Industry:** Industrial processes such as cement and steel production are important sources of CO₂ emissions, and many industrial activities are energy intensive. Low-emission alternatives are available, but financial resources are needed to develop and implement these alternatives at scale.
 - **Land use, including agriculture and forestry:** Land use changes, such as deforestation, and certain agricultural activities are large GHG emission sources. On the other hand, sustainably managed forests and ecosystems can constitute important carbon sinks.
 - **Material flows and waste:** GHG emissions can be reduced substantially by introducing circular material flows, by reducing waste streams, and by managing waste in ways that minimize methane emissions.

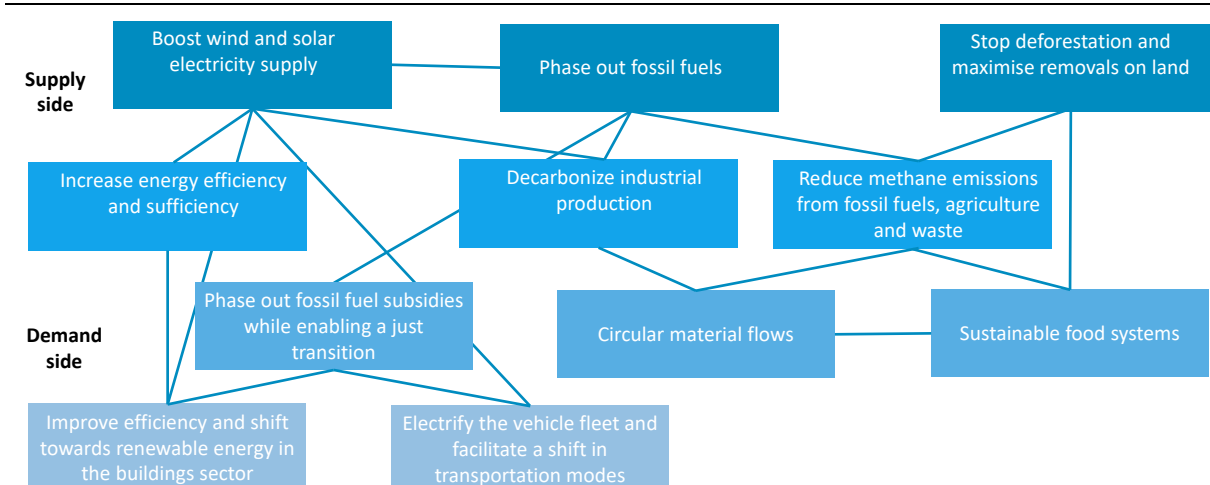
3.2 Suggested key actions and targets to be included in the outputs of the Global Stocktake

In order to make these elements as concrete as possible, but still keep them concise, we suggest formulating key mitigation actions and supporting them by concrete targets. In the following, we propose such mitigation actions and targets which could be included in the outputs of the Global Stocktake, by mentioning them in the CMA decision or a declaration, and by elaborating on them in an annex to the decision. The proposed mitigation actions are not exhaustive. The aim of the collection presented here is to provide an overview of actions which several sources have identified as having a high mitigation potential (e.g., IPCC 2022a, UNEP 2022, IEA 2022b).

Figure 2 provides an overview of these mitigation actions. As shown in the figure, the actions are interlinked. As an example, the boosting of wind and solar electricity supply facilitates the phasing out of fossil fuels. It also facilitates the shift towards renewable energy in the building sector, if combined with increased energy efficiency.

² 2030 Breakthrough, Built environment, <https://climatechampions.unfccc.int/system/builtenvironment/>

Figure 2: Suggested key mitigation actions and selected links between them



Note: The mitigation actions are roughly structured between the supply and demand side, although several actions address both supply and demand.

Source: Own illustration, Öko-Institut

In the following, possible targets are introduced for each of the key actions. Such targets have been proposed by various authors, as referenced for each target. While it is important to have targets that are as specific as possible, it is still open on which level of detail Parties may be able to agree. For several key actions, both quantitative and qualitative targets are listed.

Many of the targets proposed in recent literature cover a time horizon up to 2030. This is in line with the fact that urgent mitigation action is needed in the present decade up to 2030. As the next NDCs will cover a time period up to 2035, additional targets could be developed for that time horizon. For some mitigation actions, long-term targets up to 2050 have been proposed, which could also help in target-setting for 2035.

Besides possible targets, overview information in tabular format is provided for each key action, including core measures, indicators, contributions to emission reductions, costs, benefits and impacts.

3.2.1 Boost wind and solar electricity supply

Possible target:

- Install at least 1.5 terawatt (TW) of new wind and solar capacity per year by 2030. Total wind and solar capacity should reach around 10 TW by the end of the decade (Climate Analytics 2023, see also IRENA 2022).

The supply of electricity from wind and solar has seen important increases in many countries in recent years, and net lifetime costs of a switch to wind or solar power generation are projected to be below zero in many cases (IPCC 2022a).

The following table provides an overview of this mitigation action. The table lists core measures which can be implemented in the short term (with a 2030 horizon) and core measures which could be included in countries' next NDCs (with a 2035 horizon).

In addition, the table lists indicators for tracking progress in implementation, the potential contribution to net emission reduction and net lifetime costs (from the IPCC's Sixth Assessment Re-

port; Babiker et al. 2022), financing sources, co-benefits, social and economic impacts, and initiatives for international cooperation. It should be noted that the presented elements are not exhaustive and depend on national circumstances. Nevertheless, the table aims to provide a concise overview of some key elements of this mitigation action.

Table 2: Overview of the mitigation action ‘boost wind and solar electricity supply’

Element	Description
Core measures – short term (national governments)	Support the installation of solar power generation capacity Support the installation of wind power generation capacity Remove barriers to the expansion of renewable power generation Develop the electricity grid and storage infrastructure
Core measures – next NDC (national governments)	Set ambitious targets for installed capacity, including implementation plans
Core measures – other stakeholders	Businesses: Invest in the installation of wind and solar power generation, purchase electricity from renewable sources
Indicators	Generation of wind and solar power (absolute or percentage of total power generation) Storage capacity, load shifting capacity
Potential contribution to net emission reduction (2030)	Wind: 2.1-5.6 Gt CO ₂ eq per year Solar: 2.0-7.0 Gt CO ₂ eq per year
Net lifetime costs	Wind: < 0 USD per t CO ₂ eq (60%); 0-20 USD per t CO ₂ eq (20%); 20-50 USD per t CO ₂ eq (20%) Solar: < 0 USD per t CO ₂ eq (60%); 0-20 USD per t CO ₂ eq (13%); 20-50 USD per t CO ₂ eq (13%); 50-100 USD per t CO ₂ eq (13%)
Sources of finance flows, means of implementation and support	Targeted subsidies Purchase guarantees Low interest loans Technology transfer, capacity building
Co-benefits	Health benefits from reduced air pollution Decentralized access to electricity Job opportunities in the electricity sector Reduced water consumption in agriculture in case of collocated agriculture and solar photovoltaic infrastructure (Barron-Gafford et al. 2019).
Social and economic impacts that need to be addressed	Loss of employment opportunities in fossil-based energy industries Poor work conditions in manufacturing and mining of raw materials Stranded assets in fossil-based energy industries
Initiatives for international cooperation	Clean power breakthrough ³ as part of the ‘breakthrough agenda’ launched at the COP26 World Leaders’ Summit. Energy package proposed by the incoming COP presidency: Tripling renewable energy capacity by 2030 (Al Jaber 2023).

Sources: Own compilation. The numbers for potential contribution to net emission reduction and net lifetime costs are taken from the underlying data for the IPCC Sixth Assessment Report, Working Group III Summary for Policy Makers, Figure SPM.7 (Babiker et al. 2022).

³ Clean power – Decarbonizing the global power sector, <https://racetozero.unfccc.int/system/clean-power/>

Wind and solar electricity supply has a high mitigation potential because the technology is readily available and is available at relatively low costs (IPCC 2022a). Renewable electricity generation can provide co-benefits in many cases. If power generation from fossil fuels is replaced, improvements of air quality ensue. De-centralized renewable electricity can provide power to communities that have not yet been connected to an electrical grid, which may be the case in particular for marginalised groups.

A transformational shift of electricity sources has important impacts on those working in the energy sector. Workers at fossil fuel powered plants and those working in the production of fuels (such as coal or natural gas) are affected once the generation of electricity from fossil fuels is phased down. Hence, it will be important to support a just transition for these workers. In many countries, a phaseout may not be feasible in the short term due to high investment costs of renewable energy sources, and the overall demand for electricity may increase in the coming years. In these countries, it will be critical that any *new* electricity generating capacity will be based on renewable energy sources.

3.2.2 Increase energy efficiency and sufficiency

Possible target:

- ▶ Decrease the energy intensity of operations by 20-30% in residential buildings and by 10-30% in commercial buildings by 2030 compared to 2015 (Climate Action Tracker 2020; Boehm et al. 2022).

GHG emissions from several sectors can be reduced with improved energy efficiency of production, transmission and end use. In many cases, energy efficiency comes along with cost savings. However, upfront investments into more efficient technology may be needed before energy and cost savings can be realised.

Energy efficiency improvements apply across all sectors including, for example, using the most efficient appliances available, improving building envelopes to minimise the need for active heating or cooling, and improving the energy efficiency of industrial processes.

Particularly in developed countries, energy sufficiency – using only the energy required to meet needs – will help the achievement of decarbonisation goals by reducing overall energy demand.

Increases in efficiency often face rebounds, and higher efficiency is followed by an increased use of energy or resources. Hence the concept of sufficiency should be used as a complement to efficiency: A sufficient lifestyle makes use of available resources sparingly, without reducing the quality of life.

Table 3: Overview of the mitigation action ‘increase energy efficiency’

Element	Description
Core measures – short term (national governments)	Introduce national standards for energy efficiency Support energy efficiency improvements in various sectors of the economy Public information campaigns on energy efficiency and energy demand reduction
Core measures – next NDC (national governments)	Set ambitious targets for energy efficiency, including implementation plans Public information campaigns on sufficient lifestyles
Core measures – other stakeholders	Implement voluntary energy efficiency measures, noting the savings potential of such measures

Element	Description
Indicators	Primary or final energy consumption Energy consumption in specific sectors
Potential contribution to net emission reduction (2030)	Avoided demand for energy services: 0.28-0.84 Gt CO ₂ eq per year Efficient lighting, appliances and equipment: 0.54-0.91 Gt CO ₂ eq per year Energy efficiency in the industry sector: 0.86-1.43 Gt CO ₂ eq per year
Net lifetime costs	Avoided demand for energy services and efficient lighting, appliances and equipment: <0 USD per t CO ₂ eq (costs are lower than reference) Energy efficiency in the industry sector: 0-20 USD per t CO ₂ eq
Sources of finance flows, means of implementation and support	Targeted subsidies for energy efficiency technologies Low interest loans Technology transfer, capacity building
Co-benefits	Cost saving through lower energy consumption
Social and economic impacts that need to be addressed	No major negative impacts
Initiatives for international cooperation	Energy efficiency standards

Sources: Own compilation. The numbers for potential contribution to net emission reduction and net lifetime costs are taken from the underlying data for the IPCC Sixth Assessment Report, Working Group III Summary for Policy Makers, Figure SPM.7 (Babiker et al. 2022).

3.2.3 Phase out fossil fuels

Possible targets:

- ▶ Phase out fossil fuels across all sectors, including power, industry, transport and buildings.
- ▶ Reduce the share of unabated coal in electricity generation to 0–2.5% by 2030 and 0% by 2040 (Climate Action Tracker 2020; Boehm et al. 2022).
- ▶ Reduce the share of unabated gas in electricity generation to 17% by 2030, 5% by 2040 and 0% by 2050 (Hare et al. 2021; Boehm et al. 2022).

The combustion of fossil fuels is the main source of anthropogenic CO₂ emissions globally. Due to the long lifetime of CO₂ in the atmosphere and the limited possibilities to remove CO₂ from the atmosphere at large scale, greenhouse gas emissions from fossil fuels need to be phased out in order to limit the global temperature increase. While CO₂ emissions from the combustion or use of fossil fuels can be captured, such technologies are not available at scale in the near term, and there are open questions relating to the transport, monitoring and long-term storage of CO₂. Hence, it is important to phase out the combustion and use of fossil fuels overall.

Table 4: Overview of the mitigation action ‘phase out fossil fuels’

Element	Description
Core measures – short term (national governments)	Phase-out plans for fossil fuel powerplants Stop new fossil fuel infrastructure projects
Core measures – next NDC (national governments)	Accelerated phase-out Decommission fossil fuel infrastructure
Core measures – other stakeholders	Stop new fossil fuel infrastructure projects
Indicators	Share of fossil fuels in primary energy production
Potential contribution to net emission reduction (2030)	No data available for this particular mitigation action
Net lifetime costs	No data available for this particular mitigation action
Sources of finance flows, means of implementation and support	Compensation payments Market and regulatory mechanisms International support, including Just Energy Transition Partnerships
Co-benefits	Health benefits from reduced air pollution
Social and economic impacts that need to be addressed	Loss of employment opportunities in fossil-based energy industries Stranded assets in fossil-based energy industries
Initiatives for international cooperation	Just Energy Transition Partnerships Powering Past Coal alliance ⁴ Beyond Oil & Gas Alliance ⁵

Source: Own compilation.

3.2.4 Phase out fossil fuel subsidies while enabling a just transition

Possible target:

- ▶ Eliminate fossil fuel subsidies by 2030 (Systems Change Lab 2023).

Fossil fuels are subsidised in many parts of the world. In order to support a transition towards non-fossil energy systems, such subsidies need to be phased out. However, such a phase out has to ensure that needs for energy and mobility are still met.

⁴ Powering Past Coal Alliance, <https://poweringpastcoal.org/>

⁵ Beyond Oil and Gas Alliance, <https://beyondoilandgasalliance.org/>

Table 5: Overview of the mitigation action ‘phase out fossil fuel subsidies while enabling a just transition’

Element	Description
Core measures – short term (national governments)	Phase out subsidies Provide support for alternative fuels Provide support for alternative transportation modes
Core measures – next NDC (national governments)	Increase the availability of alternative transportation modes
Core measures – other stakeholders	---
Indicators	---
Potential contribution to net emission reduction (2030)	No data available for this particular mitigation action
Net lifetime costs	No data available for this particular mitigation action
Sources of finance flows, means of implementation and support	With the reduction of subsidies, financial resources become available for the support of alternative energy or transportation
Co-benefits	Availability of additional financial resources
Social and economic impacts that need to be addressed	Higher costs for energy Higher costs for transportation
Initiatives for international cooperation	---

Source: Own compilation.

3.2.5 Electrify the vehicle fleet and facilitate a shift in transportation modes

Possible targets:

- ▶ Increase the share of electric vehicles in total annual light duty vehicle sales to 75–95% by 2030 and 100% by 2050 (Boehm et al. 2022; Climate Action Tracker 2020).
- ▶ Expand the share of electric vehicles to account for 20–40% of the total light duty vehicle fleet by 2030 (Boehm et al. 2022; Climate Action Tracker 2020).
- ▶ Boost the share of battery and fuel cell electric vehicles to 60% of annual global bus sales by 2030 (Boehm et al. 2022; IEA 2021).
- ▶ Double rapid transit infrastructure by 2030, relative to 2021 (Teske et al. 2021; Boehm et al. 2022).

Electric vehicles constitute an alternative to vehicles with combustion engines and can contribute important GHG emission reductions, provided that electricity is available from a low-GHG

energy mix. Besides a shift in technology, transport demand should be addressed through for example smart spatial planning and demand shifted to sustainable modes, such as public transport or cycling and walking. Such demand-side options can reduce transport sector emissions in developed countries and limit emissions growth in developing countries (IPCC 2022b).

In addition, aviation and maritime transport contribute to GHG emissions with increasing trends. While these emissions are addressed at the international level by specialized agencies, demand and emissions should still be curbed by actions at the national level.

Table 6: Overview of the mitigation action ‘electrify the vehicle fleet and facilitate a shift in transportation modes’

Element	Description
Core measures – short term (national governments)	Incentivise a shift towards electric vehicles through regulations, pricing schemes or subsidies Provide charging infrastructure Expand public transport Provide an environment for sustainable transportation modes such as walking and cycling
Core measures – next NDC (national governments)	Further expand public transport
Core measures – other stakeholders	Private sector: Replace vehicles with internal combustion engines by electric vehicles, increase the use of sustainable modes of transport, reduce distances travelled where possible Citizens: Increase the use of sustainable modes of transport
Indicators	Share of vehicles powered by renewable energy Share of newly registered electric vehicles Number of e-mobility charging stations Passenger kilometres and tonne kilometres using various modes of transport
Potential contribution to net emission reduction (2030)	Electric light duty vehicles: 0.30-0.89 Gt CO ₂ eq per year Shift to public transportation: 0.27-0.80 Gt CO ₂ eq per year Shift to bikes and e-bikes: 0.10-0.29 Gt CO ₂ eq per year Electric heavy-duty vehicles: 0.11-0.32 Gt CO ₂ eq per year
Net lifetime costs	<0 USD per t CO ₂ eq for shift to public transport, bikes and e-bikes (costs are lower than reference) For electric vehicles, no costs were provided by Babiker et al. (2022) due to high variability or lack of data
Sources of finance flows, means of implementation and support	Tax rebates for new electric vehicles Higher taxes/charges for vehicles with internal combustion engines
Co-benefits	Health benefits from reduced air pollution Health benefits from walking and cycling
Social and economic impacts that need to be addressed	Costs of electric vehicles Inequalities in the access to charging infrastructure or transportation modes

Element	Description
Initiatives for international cooperation	Global road transport breakthrough ⁶ as part of the ‘breakthrough agenda’ launched at the COP26 World Leaders’ Summit.

Sources: Own compilation. The numbers for potential contribution to net emission reduction and net lifetime costs are taken from the underlying data for the IPCC Sixth Assessment Report, Working Group III Summary for Policy Makers, Figure SPM.7 (Babiker et al. 2022).

3.2.6 Improve efficiency and shift towards renewable energy in the buildings sector

Possible targets:

- ▶ Reduce the carbon intensity of building operations to 15-21 kg CO₂/m² in commercial buildings and 10-16 kg CO₂/m² in residential buildings by 2030. Eliminate fossil fuels in building operations by 2050 (Boehm et al. 2022; Climate Action Tracker 2020).
- ▶ Phase out new fossil fuel boilers for space and water heating by 2025 (IEA 2022b).
- ▶ All new buildings should be zero carbon in operation as of now⁷ (Climate Action Tracker 2020).

The construction, heating and cooling of building is energy-intensive and is an important source of GHG emissions. While low-emission building materials and efficient heating and cooling options are available, this sector faces the challenge that high investments are needed to reduce GHG emissions at scale. Efficient use of the available infrastructure and a lifestyle focused on sufficiency can contribute.

Table 7: Overview of the mitigation action ‘shift towards renewable energy in the buildings sector’

Element	Description
Core measures – short term (national governments)	Provide financial support to the retrofitting of buildings Enhance building codes and appliance performance standards Scale up zero-emission heating and cooling technology Phase out any fossil fuel subsidies
Core measures – next NDC (national governments)	Continue with providing financial support to the retrofitting of buildings
Core measures – other stakeholders	Private sector: Invest in the retrofitting of buildings Private sector and citizens: Use energy efficiently, avoiding unnecessary heating and cooling
Indicators	Annual renovation rate of buildings Energy consumption per household or per area of commercial building CO ₂ emissions per area

⁶ Global Road Transport – Towards a just, clean and accessible mobility system for all, <https://racezero.unfccc.int/system/ROAD-TRANSPORT/>

⁷ This target recognizes that full decarbonisation of building operations relies on a zero-carbon power system. This target means that all new buildings should be fully dependent on direct renewable energy or electricity for energy needs. The International Energy Agency commonly refers to these buildings as ‘zero carbon ready’, i.e. they will be zero carbon as soon as the power grid is fully decarbonized.

Element	Description
Potential contribution to net emission reduction (2030)	Avoid demand for energy services: 0.28-0.84 Gt CO ₂ eq per year Efficient lighting, appliances and equipment: 0.54-0.91 Gt CO ₂ eq per year New buildings with high energy performance: 0,88-1.77 Gt CO ₂ eq per year Onsite renewable production and use: 0.35-0.70 Gt CO ₂ eq per year Improvement of existing building stock: 0.20-0.34 Gt CO ₂ eq per year Enhanced use of wood products: 0.3-0.5 Gt CO ₂ eq per year
Net lifetime costs	Avoid demand for energy services; and efficient lighting, appliances and equipment: <0 USD per t CO ₂ eq for (costs are lower than reference) New buildings with higher energy performance: 0-20 USD per t CO ₂ eq (10%); 20-50 USD per t CO ₂ eq (10%); 50-100 USD per t CO ₂ eq (10%); 100-200 USD per t CO ₂ eq (70%) Onsite renewable production and use: 0-20 USD per t CO ₂ eq (14%); 20-50 USD per t CO ₂ eq (14%); : 50-100 USD per t CO ₂ eq (14%); 100-200 USD per t CO ₂ eq (57%) Improvement of existing building stock: 0-20 USD per t CO ₂ eq (25%); 20-50 USD per t CO ₂ eq (25%); 50-100 USD per t CO ₂ eq (25%); 100-200 USD per t CO ₂ eq (25%) No costs allocated by Babiker et al. (2022) for enhanced use of wood products
Sources of finance flows, means of implementation and support	Subsidies Purchase guarantees
Co-benefits	Health benefits from reduced air pollution Cost benefits from energy savings
Social and economic impacts that need to be addressed	No major negative impacts
Initiatives for international cooperation	C40 Net Zero Carbon Buildings Accelerator ⁸

Sources: Own compilation. The numbers for potential contribution to net emission reduction and net lifetime costs are taken from the underlying data for the IPCC Sixth Assessment Report, Working Group III Summary for Policy Makers, Figure SPM.7 (Babiker et al. 2022).

3.2.7 Decarbonize industrial production

Possible targets:

- ▶ Increase the share of electricity in the industry sector's final energy demand to 35% (Boehm et al. 2022; Climate Action Tracker 2020).
- ▶ Reduce the carbon intensity of global cement production to 360-370 kg CO₂ per tonne of cement by 2030 and 55-90 kg CO₂ per tonne of cement by 2050 (Boehm et al. 2022; Climate Action Tracker 2020).
- ▶ Reduce the carbon intensity of global steel production to 1335-1350 kg CO₂ per tonne of steel by 2030 and 0-130 kg CO₂ per tonne of steel by 2050 (Boehm et al. 2022; Climate Action Tracker 2020).

⁸ Net Zero Carbon Buildings Accelerator, <https://www.c40.org/accelerators/net-zero-carbon-buildings/>

Industrial processes such as cement and steel production are energy-intensive and contribute to GHG emissions. Low-emission technologies are available, but high investments are needed to make them available at scale.

Table 8: Overview of the mitigation action ‘decarbonize industrial production’

Element	Description
Core measures – short term (national governments)	Support the implementation of zero-carbon industrial processes Increase circularity Create lead markets for green materials Create market and regulatory mechanisms that incentivize industrial decarbonisation Support investments in research and development and commercial demonstrator plants
Core measures – next NDC (national governments)	Scale up process based on electricity and hydrogen Substitute materials Innovation in production processes Scale up carbon capture and storage
Core measures – other stakeholders	Private sector: Install low and zero-carbon technologies when replacing existing technologies
Indicators	GHG emissions per unit of product Share of renewable energy sources in final energy demand
Potential contribution to net emission reduction (2030)	Feedstock decarbonisation, process change: 0.29-0.48 Gt CO ₂ eq per year Carbon capture with utilisation and carbon capture with storage: 0.11-0.36 Gt CO ₂ eq per year Cementitious material substitution: 0.21-0.35 Gt CO ₂ eq per year Reduction of non-CO ₂ emissions: 0.15-0.25 Gt CO ₂ eq per year
Net lifetime costs	Feedstock decarbonisation, process change: 50-100 USD per t CO ₂ eq Carbon capture with utilisation and carbon capture with storage: 100-200 USD per t CO ₂ eq Cementitious material substitution: 20-50 USD per t CO ₂ eq Reduction of non-CO ₂ emissions: 0-20 USD per t CO ₂ eq
Sources of finance flows, means of implementation and support	Subsidies Purchase guarantees
Co-benefits	Reduced air pollution (e.g. electric arc furnace instead of Blast Furnace-Basic Oxygen Furnace)
Social and economic impacts that need to be addressed	Shift of employment opportunities in industry

Element	Description
Initiatives for international cooperation	Industry breakthroughs ⁹ as part of the ‘breakthrough agenda’ launched at the COP26 World Leaders’ Summit. For detailed information on organisations providing governance and initiatives in the industry sector, see Otto and Oberthür (2022).

Sources: Own compilation. The numbers for potential contribution to net emission reduction and net lifetime costs are taken from the underlying data for the IPCC Sixth Assessment Report, Working Group III Summary for Policy Makers, Figure SPM.7 (Babiker et al. 2022).

3.2.8 Circular material flows

Possible targets:

- ▶ Set recycling rates for energy-intensive materials and those which generate GHG emissions during production or disposal.
- ▶ Set targets for sustainable production and consumption or waste reduction.
- ▶ Foster circular product design and the increase of product lifespans.

Note that there is a considerable overlap with the mitigation actions ‘decarbonize industrial production’ (section 3.2.7) and ‘reduce methane emissions from fossil fuels, agriculture and waste’ (section 3.2.9). Data and further details can be found in these sections.

The re-use of materials helps reduce GHG emissions during production and disposal of materials and goods.

The following table provides an overview of this mitigation action.

Table 9: Overview of the mitigation action ‘circular material flows’

Element	Description
Core measures – short term (national governments)	Develop and implement regulations for the recycling of materials Develop and implement regulations for re-usable goods
Core measures – next NDC (national governments)	Continue closing gaps in circular material flows
Core measures – other stakeholders	Participate actively in the circular economy
Indicators	---
Potential contribution to net emission reduction (2030)	No data available for this particular mitigation action
Net lifetime costs	No data available for this particular mitigation action

⁹ Industry breakthroughs, <https://climatechampions.unfccc.int/system/industry/>

Element	Description
Sources of finance flows, means of implementation and support	Subsidies
Co-benefits	Longevity of products Reduced pollution from consumption and disposal
Social and economic impacts that need to be addressed	No major negative impacts
Initiatives for international cooperation	---

Source: Own compilation.

3.2.9 Reduce methane emissions from fossil fuels, agriculture and waste

Possible targets:

- ▶ Meet the Global Methane Pledge globally and reduce methane emissions by at least 30 per cent from 2020 levels by 2030 (Global Methane Pledge 2023).
- ▶ Set sector-specific targets which go beyond the targets of the Global Methane Pledge.

Methane (CH₄) is the second most important greenhouse gas after carbon dioxide (CO₂). While it does not remain in the atmosphere as long as CO₂, its radiative forcing is higher. Methane emissions can be reduced and avoided in several sectors, and many of these mitigation actions offer important co-benefits, from cost savings to health benefits.

The following table provides an overview of this mitigation action.

Table 10: Overview of the mitigation action ‘reduce methane emissions from fossil fuels, agriculture and waste’

Element	Description
Core measures – short term (national governments)	Strengthen regulations for monitoring and leak prevention Provide incentives for low-methane agricultural practices Replace landfilling by other waste management approaches such as recycling or incineration with energy use Invest in the capturing of methane from landfills
Core measures – next NDC (national governments)	Provide incentives for low-methane agricultural practices Replace landfilling by other waste management approaches such as recycling or incineration with energy use Invest in the capturing of methane from landfills
Core measures – other stakeholders	Private sector: Set up monitoring and leak prevention
Indicators	Methane emissions per unit of fuel produced or transported Total methane emissions from the agriculture sector Total methane emissions from the waste sector

Element	Description
Potential contribution to net emission reduction (2030)	Reduce CH ₄ emissions from coal mining: 0.21-0.68 Gt CO ₂ eq per year Reduce CH ₄ emissions from oil and gas: 0.67-1.61 Gt CO ₂ eq per year Reduce CH ₄ and N ₂ O emissions in agriculture: 0.3-1.3 Gt CO ₂ eq per year. Note: The source of the data provides the total contribution of CH ₄ and N ₂ O. The contribution of CH ₄ is not available separately. Reduce CH ₄ emissions from solid waste: 0.54-0.68 Gt CO ₂ eq per year Reduce CH ₄ emissions from wastewater: 0.09-0.27 Gt CO ₂ eq per year
Net lifetime costs	Reduce CH ₄ emissions from coal mining: <0 USD per t CO ₂ eq (8%); 0-20 USD per t CO ₂ eq (82%); 20-50 USD per t CO ₂ eq (6%); 50-100 USD per t CO ₂ eq (4%) Reduce CH ₄ emissions from oil and gas: <0 USD per t CO ₂ eq (27%); 0-20 USD per t CO ₂ eq (53%); 20-50 USD per t CO ₂ eq (6%); 50-100 USD per t CO ₂ eq (5%); 100-200 USD per t CO ₂ eq (9%) Reduce CH ₄ and N ₂ O emissions in agriculture: 0-20 USD per t CO ₂ eq (15%); 20-50 USD per t CO ₂ eq (21%); 50-100 USD per t CO ₂ eq (64%). Note: The source of the data provides the total contribution of CH ₄ and N ₂ O. The contribution of CH ₄ is not available separately. Reduce CH ₄ emissions from solid waste: <0 USD per t CO ₂ eq (53%); 0-20 USD per t CO ₂ eq (18%); 20-50 USD per t CO ₂ eq (10%); 50-100 USD per t CO ₂ eq (6%); 100-200 USD per t CO ₂ eq (13%) Reduce CH ₄ emissions from wastewater: <0 USD per t CO ₂ eq (11%); 0-20 USD per t CO ₂ eq (16%); 20-50 USD per t CO ₂ eq (21%); 50-100 USD per t CO ₂ eq (16%); 100-200 USD per t CO ₂ eq (37%)
Sources of finance flows, means of implementation and support	Technology transfer Private sector investments for measures that reduce natural gas losses
Co-benefits	Cost benefits from the reduction of natural gas losses Health benefits from a reduction of ruminant meat consumption
Social and economic impacts that need to be addressed	Loss of employment opportunities in methane-intensive agricultural activities such as stock farming
Initiatives for international cooperation	Global Methane Pledge ¹⁰

Sources: Own compilation. The numbers for potential contribution to net emission reduction and net lifetime costs are taken from the underlying data for the IPCC Sixth Assessment Report, Working Group III Summary for Policy Makers, Figure SPM.7 (Babiker et al. 2022).

3.2.10 Stop deforestation and maximise removals on land

Possible targets:

- ▶ Reduce the annual rate of gross deforestation globally to 1.9 million hectares per year in 2030 (Boehm et al. 2022; Roe et al. 2019).
- ▶ Reforest an area of 100 million hectares between 2020 and 2030 (Boehm et al. 2022).

¹⁰ Global Methane Pledge, <https://www.globalmethanepledge.org/>

In many countries, deforestation constitutes a large source of CO₂ emissions, and land use or land use changes can lead to important GHG emissions. On the other hand, sustainable management can turn forests and other land into net sinks of CO₂ and constitute a vital contribution to climate change mitigation.

The following table provides an overview of this mitigation action.

Table 11: Overview of the mitigation action ‘stop deforestation and maximise removals on land’

Element	Description
Core measures – short term (national governments)	Prevent deforestation Support reforestation with a long-term perspective Expand conservation areas Implement sustainable land use and management plans
Core measures – next NDC (national governments)	Support reforestation with a long-term perspective Expand conservation areas Implement sustainable land use and management plans Consider novel removal techniques, such as direct air capture, with long-term storage of carbon
Core measures – other stakeholders	Private sector: Use private land, such as forests, sustainably Private sector: Reforest areas with a long-term perspective
Indicators	Reforested area Restored area Amount of CO ₂ removed
Potential contribution to net emission reduction (2030)	Carbon sequestration in agriculture: 1.4-5.5 Gt CO ₂ eq per year Reduce CH ₄ and N ₂ O emission in agriculture: 0.3-1.3 Gt CO ₂ eq per year Reduce conversion of forests and other ecosystems: 2.53-7.35 Gt CO ₂ eq per year Ecosystem restoration, afforestation, reforestation: 1.2-4.9 Gt CO ₂ eq per year Improved sustainable forest management: 0.6-2.8 Gt CO ₂ eq per year
Net lifetime costs	Carbon sequestration in agriculture: 0-20 USD per t CO ₂ eq (15%); 20-50 USD per t CO ₂ eq (21%); 50-100 USD per t CO ₂ eq (64%) Reduce CH ₄ and N ₂ O emission in agriculture: 0-20 USD per t CO ₂ eq (56%); 50-100 USD per t CO ₂ eq (44%) Reduce conversion of forests and other ecosystems: 0-20 USD per t CO ₂ eq (57%); 20-50 USD per t CO ₂ eq (3%); 50-100 USD per t CO ₂ eq (40%) Ecosystem restoration, afforestation, reforestation: 0-20 USD per t CO ₂ eq (5%); 20-50 USD per t CO ₂ eq (20%); 50-100 USD per t CO ₂ eq (51%); 100-200 USD per t CO ₂ eq (23%) Improved sustainable forest management: 0-20 USD per t CO ₂ eq (28%); 50-100 USD per t CO ₂ eq (57%); 100-200 USD per t CO ₂ eq (16%)
Sources of finance flows, means of implementation and support	Carbon markets
Co-benefits	Protection of biodiversity
Social and economic impacts that need to be addressed	Loss of employment opportunities in logging or possibly agriculture.

Element	Description
Initiatives for international cooperation	Glasgow Leaders' Declaration on Forest and Land Use High Ambition Coalition for Nature and People ¹¹ United Nations Convention on Biodiversity and Kunming-Montreal Global Biodiversity Framework

Sources: Own compilation. The numbers for potential contribution to net emission reduction and net lifetime costs are taken from the underlying data for the IPCC Sixth Assessment Report, Working Group III Summary for Policy Makers, Figure SPM.7 (Babiker et al. 2022).

3.2.11 Sustainable food systems

Possible targets:

- ▶ Shift toward a global food system for all that meets dietary needs while minimising GHG emissions, enhancing carbon sinks and avoiding adverse impacts on biodiversity.
- ▶ Reduce the share of food production that is lost to 7% per year and reduce food waste to 61 kg per capita per year (Boehm et al. 2022; United Nations 2023).

Food production is an important source of GHG emissions, inter alia through land use change, enteric fermentation and manure management. These emissions depend on the type of food produced and consumed and are substantially lower for plant-based diets. Hence changes in lifestyle can contribute to a decrease in these emissions.

Table 12: Overview of the mitigation action 'sustainable food systems'

Element	Description
Core measures – short term (national governments)	Provide incentives for sustainable agricultural practices Facilitate lifestyle changes including towards lower meat consumption Initiatives to reduce food waste
Core measures – next NDC (national governments)	Continue facilitating lifestyle changes including towards lower meat consumption
Core measures – other stakeholders	Citizens: Reduce food waste, reduce per capita ruminant meat consumption in countries where consumption is currently high
Indicators	Share of food production that is lost Food waste per capita per year
Potential contribution to net emission reduction (2030)	Reduce food loss and food waste: 0.1-0.9 Gt CO ₂ eq per year Shift to balanced, sustainable healthy diets: 1.0-2.7 Gt CO ₂ eq per year
Net lifetime costs	No costs allocated by Babiker et al. (2022)
Sources of finance flows, means of implementation and support	Subsidies for sustainable agricultural practices

¹¹ High Ambition Coalition for People and Nature, <https://www.hacfornatureandpeople.org/home>

Element	Description
Co-benefits	Health benefits from lower meat consumption, cost benefits from the reduction of food waste Changes in farming practices may increase adaptative capacity
Social and economic impacts that need to be addressed	Loss of job opportunities in the meat processing industry
Initiatives for international cooperation	---

Sources: Own compilation. The numbers for potential contribution to net emission reduction and net lifetime costs are taken from the underlying data for the IPCC Sixth Assessment Report, Working Group III Summary for Policy Makers, Figure SPM.7 (Babiker et al. 2022).

3.3 Discussion

The mitigation actions proposed here cover all relevant sectors where GHG emissions occur. Depending on national circumstances, some of the proposed actions may not be relevant for a particular country, while additional actions may have an important mitigation potential.

Additional mitigation actions

In particular, mitigation actions could address the greenhouse gas N₂O in the industry and agriculture sectors. As these actions depend on specific circumstances and the mitigation potential may be limited in some countries, they were not listed as a main mitigation action here.

Fluorinated gases (F-gases), which are used in industry and for refrigeration, significantly contribute to GHG emissions in many countries. A key group of these gases, hydrofluorocarbons, is addressed by the Kigali Amendment to the Montreal Protocol (UNEP 2016). Nevertheless, it is important to implement ambitious actions to reduce the emissions of all F-gases.

Transformative potential of mitigation actions

According to the IPCC (IPCC 2022a, Table 13.2) climate change mitigation policies can be seen as having transformative potential if they can fundamentally change emissions trajectories or facilitate technologies, practices or products with far lower emissions. Hermwille et al. (2015) pointed out that a transformative policy instrument should have impact beyond its immediate scope, such as contributing to a build-up of capacities, advancing wider political and social debates and leading to a diversion of investments into sustainable technologies.

The definition of specific criteria for what constitutes a transformative mitigation action is challenging, and some Parties and stakeholders may decide to pursue actions which do not fulfil such criteria. Here, we list some criteria, but other criteria may be more relevant in a specific context.

- **High mitigation potential:** A high mitigation potential means that an action reduces GHG emissions or removes GHGs from the atmosphere at a large scale, and these reductions or removals can be achieved within a timeframe of a few years. Only large-scale and rapid reductions can put GHG emissions on a trajectory which is in line with reaching the temperature goal of the Paris Agreement (IPCC 2021). However, it has to be taken into account that some low-cost emission reduction potentials may lead to lock-in and impede deep decarbonization later on (e.g., a switch from coal to fossil gas in power generation).

- ▶ **Low investment and/or lifetime costs:** The mitigation action can be implemented by many actors without incurring high costs. A wide range of cost-effective mitigation action exist, but relative potentials and costs vary across countries and over time (IPCC 2022b). While renewable energy generation comes with low operating costs in many cases, it may require high upfront investments. Many mitigation actions in the industry sector also require high investments. In the buildings sector, actions such as thermal insulation requires up-front investments but generate long-term savings. With all mitigation options, it is important to consider how funding and the access to funding can be improved and widened.
- ▶ **Co-benefits:** The mitigation action provides co-benefits, as far as this is feasible. Co-benefits could include, inter alia, the areas of adaptation to climate change, health, poverty reduction or food security.
- ▶ **Enable a just transition:** Any negative social or economic consequences and impacts of the mitigation action have to be minimized. Only if such impacts are minimized, a just transition towards a low GHG emissions economy is possible.
- ▶ **Implementation at various levels:** The mitigation action needs to be ready to be implemented at scale, and if possible, at various levels (global, national, local and/or at the demand-side).

Challenges

The implementation of each of the proposed mitigation actions faces challenges. These are often case-specific, but experiences gained with the implementation of such action in other countries can help overcome these challenges.

The main challenge of most transformative actions is that they require regulatory changes and financial resources for implementation, and they need to be accepted by the citizens affected. As some countries already implemented such measures successfully, it becomes easier for others to adopt regulatory changes and gain acceptance. Costs of new technologies decrease over time, as it is the case, e.g., for wind and solar power generation.

Financial support and technology transfer are key to help developing countries in implementing many of the proposed actions. However, support provided by other countries is only one element, and building the enabling environment and facilitating finance flows, including from the private sector, is required as well.

Addressing social and economic consequences and impacts of mitigation actions

Any transformative action brings about disruptive change. Hence it is key to address the social and economic consequences and impacts of such actions. While many mitigation actions have positive social and economic impacts overall (i.e., co-benefits), others have negative effects on workers, businesses, specific social groups and/or the general public.

When implementing the mitigation actions listed above, Parties need to provide for a just transition. In particular for measures in the energy sector, alternatives need to be provided for workers in the fossil fuel industry and the communities which evolved around these industries. Likewise, changes in industry or land use affect the workforce, and workers need to be provided new perspectives and employment opportunities.

It is important for all Parties and stakeholders to acknowledge the size of the task ahead. With careful planning and making use of available experience, transformative change can be brought about. The Global Stocktake needs to make it very clear that such change is required to keep the goals of the Paris Agreement within reach – and that it is possible if decisive action is taken.

4 Informing new NDCs and enhancing ambition

4.1 Options for including elements in the outputs of the Global Stocktake

Specific elements relating to mitigation could be added in various ways in the outputs of the Global Stocktake:

- ▶ As a basic option, statements on mitigation efforts in various sectors could be formulated as broad statements of intent, similar to the wording in the CMA cover decisions of Glasgow and Sharm El-Sheikh. However, it will be important that the wording reflects higher ambition compared to what was already agreed earlier.
- ▶ In addition, Parties could include targets for key mitigation actions in the various sectors. In case Parties cannot agree on ambitious targets in the CMA decision text, such targets could be included in separate declarations. Again, it will be critical that the wording reflects the highest possible ambition and goes beyond earlier agreements.
- ▶ Parties could name sector-specific measures to be considered when preparing their next NDC. Noting that mitigation actions in the energy and land sectors have already been included in earlier CMA decisions, the CMA should strive to agree on actions which are widely seen as suitable for rapid GHG emission reduction in specific sectors.
- ▶ Additional information on key mitigation actions could be provided in a technical annex. However, it is important that such an annex not only constitutes a general compilation of information but includes targeted information that facilitates the rapid implementation of actions by Parties and non-Party stakeholders.

No matter which options are finally chosen for addressing mitigation in the outputs of the Global Stocktake, the following aspects need to be taken into account:

- ▶ The messages on mitigation need to address both the time horizon up to 2030 and the time horizon of new NDCs, up to 2035.
- ▶ The messages on mitigation need to provide guidance for Parties on how to take into account the outputs of the Global Stocktake in their new NDCs.

4.2 Steps to be taken in response to the outputs of the Global Stocktake

According to Article 14 of the Paris Agreement, the outcome of the Global Stocktake shall inform Parties in updating and enhancing their actions and support. Besides the call for specific actions and targets, the outputs of the Global Stocktake should contain guidance to Parties on how to select, plan and implement them.

In this chapter, we propose some elements of such guidance, focussing on mitigation aspects. The following table shows suggested steps which Parties could take in response to the Global Stocktake.

Table 13: Main steps to be taken in response to the Global Stocktake in the area of mitigation

Step	Description
Assess feasibility of proposed actions	For each of the main mitigation actions proposed or included in the outputs of the Global Stocktake, assess how they could be implemented.
Explore additional actions	Explore additional actions which can help mitigate climate change in the national context.
Assess social and economic impacts	Assess social and economic consequences and impacts of these mitigation actions, maximise positive impacts and minimise negative impacts.
Address barriers and enablers	Evaluate barriers and how to overcome them. Evaluate enablers and how to use them.
Set targets and plan mitigation actions	Set targets which correspond to the highest possible ambitions and plan mitigation actions accordingly. Plan targets and implementation: <ul style="list-style-type: none"> - for the time horizon up to 2030; and - for the time horizon up to 2035.
Align with long-term strategies and goals	Ensure that the targets and actions are aligned with any long-term low GHG emission strategy or long-term goal.
Address finance flows	Assess financial resources, support needs (if applicable) and ways of mobilising additional and redirecting current finance flows to implement the mitigation actions.
International cooperation	Assess ways of making use of international cooperation to further increase ambition. Use actions and targets planned by other countries as benchmarks, where relevant.
Update current NDCs (2030 horizon)	Based on the planned mitigation actions, update the mitigation target in the current NDC and communicate an updated NDC.
Prepare new NDCs (2035 horizon)	Define a new mitigation target for the next NDC and communicate it.
Implement the mitigation actions	Implement the mitigation actions in line with the assessment and plan above.

Source: Own compilation.

In this discussion paper, we suggest that the Global Stocktake should provide key targets for sectoral decarbonisation and recommend specific actions to be taken. To make sure that these are actually taken up by Parties, the outputs of the Global Stocktake should also request Parties to indicate in their NDCs how they will contribute to these targets. This would mirror the obligation of Parties to provide information on 'how the Party's preparation of its nationally determined contribution has been informed by the outcomes of the global stocktake' (Annex I to decision 4/CMA.1, UNFCCC 2018b).

When Parties prepare their NDCs and later report on progress in implementing and achieving them, they use indicators for tracking progress. Parties could include indicators for the various key targets in their reporting. The information in Parties' reports, together with reports such as the State of Climate Action Report (Boehm et al. 2022) and data from relevant organisations such as the International Energy Agency, can help tracking progress towards achieving these key targets, and hence the contribution to achieving the temperature goal of the Paris Agreement.

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