IPCC AR6 WGIII Second Order Draft Government and Expert Review Comments Responses (Entire Report)

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Comment ID	From Page	From Line	To Page	To Line	Comment	Reviewer	Country	Chapter Team Response
3513	0	9	0	9	In Annex A: Glossary, page A - 9, after carbon stock definition, please add a new definition: "Carbonation Hydrated cement used in concrete or mortars naturally absorbs carbon dioxide during its lifetime, a physicochemical process known as carbonation, thus removing carbon from the atmosphere. This permanently locks carbon dioxide, providing a stable long-term carbon dioxide storage solution. The process can even boost concrete strength by increasing the density of its pore structure. (CEMBUREAU 2020; Sanjuán et al 2020; Andrade and Sanjuán 2018) See also Recarbonation". CEMBUREAU 2020. https://lowcarboneconomy.cembureau.eu/5-years-on/the-5c-approach/recarbonation/ Sanjuán, M.Á.; Andrade, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake by Cement-Based Materials: A Spanish Case Study. Appl. Sci. 2020, 10, 339. https://doi.org/10.3390/app10010339 Andrade C, Sanjuán MA. Updating Carbon Storage Capacity of Spanish Cements. Sustainability 2018;10:4806.	Miguel Angel Sanjuán	Spain	Rejected. Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.
7509	0		0		There is concern about the extent to which assessment statements (using the calibrated confidence language) are used in the WGIII SOD. A search across the report indicates that the bulk of the assessment statements are in the executive summaries with only a limiited number in the SOD chapters themselves.	Debra Roberts	South Africa	Thank you for your comment. Assessment statements are now been revised/ added in the FGD chapters
10403	0	9	0	9	In Annex A: Glossary, page A - 9, after carbon stock definition, please add a new definition: "Carbonation Hydrated cement used in concrete or mortars naturally absorbs carbon dioxide during its lifetime, a physicochemical process known as carbonation, thus removing carbon from the atmosphere. This permanently locks carbon dioxide, providing a stable long-term carbon dioxide storage solution. The process can even boost concrete strength by increasing the density of its pore structure. (CEMBUREAU 2020; Sanjuán et al 2020; Andrade and Sanjuán 2018) See also Recarbonation". CEMBUREAU 2020. https://lowcarboneconomy.cembureau.eu/5-years-on/the-5c-approach/recarbonation/ Sanjuán, M.Á.; Andrade, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake by Cement-Based Materials: A Spanish Case Study. Appl. Sci. 2020, 10, 339. https://doi.org/10.3390/app10010339 Andrade C, Sanjuán MA. Updating Carbon Storage Capacity of Spanish Cements. Sustainability 2018;10:4806.	Aniceto Zaragoza	Spain	Rejected. Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.
10897	0	9	0	9	In Annex A: Glossary, page A - 9, after carbon stock definition, please add a new definition: "Carbonation Hydrated cement used in concrete or mortars naturally absorbs carbon dioxide during its lifetime, a physicochemical process known as carbonation, thus removing carbon from the atmosphere. This permanently locks carbon dioxide, providing a stable long-term carbon dioxide storage solution. The process can even boost concrete strength by increasing the density of its pore structure. (CEMBUREAU 2020; Sanjuán et al 2020; Andrade and Sanjuán 2018) See also Recarbonation". CEMBUREAU 2020. https://lowcarboneconomy.cembureau.eu/5-years-on/the-5c-approach/recarbonation/ Sanjuán, M.Á.; Andrade, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake by Cement-Based Materials: A Spanish Case Study. Appl. Sci. 2020, 10, 339. https://doi.org/10.3390/app10010339 Andrade C, Sanjuán MA. Updating Carbon Storage Capacity of Spanish Cements. Sustainability 2018;10:4806.	Aniceto Zaragoza	Spain	Rejected. Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.
10899	0	9	0	9	In Annex A: Glossary, page A - 9, after carbon stock definition, please add a new definition: "Carbonation Hydrated cement used in concrete or mortars naturally absorbs carbon dioxide during its lifetime, a physicochemical process known as carbonation, thus removing carbon from the atmosphere. This permanently locks carbon dioxide, providing a stable long-term carbon dioxide storage solution. The process can even boost concrete strength by increasing the density of its pore structure. (CEMBUREAU 2020; Sanjuán et al 2020; Andrade and Sanjuán 2018). See also Recarbonation". CEMBUREAU 2020. https://lowcarboneconomy.cembureau.eu/5-years-on/the-5c-approach/recarbonation/ Sanjuán, M.Á.; Andrade, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake by Cement-Based Materials: A Spanish Case Study. Appl. Sci. 2020, 10, 339. https://doi.org/10.3390/app10010339 Andrade C, Sanjuán MA. Updating Carbon Storage Capacity of Spanish Cements. Sustainability 2018;10:4806. https://doi.org/10.3390/su10124806	Aniceto Zaragoza	Spain	Rejected. Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.

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10911	0	9	0	9	In Annex A: Glossary, page A - 9, after carbon stock definition, please add a new definition: "Carbonation Hydrated cement used in concrete or mortars naturally absorbs carbon dioxide during its lifetime, a physicochemical process known as carbonation, thus removing carbon from the atmosphere. This permanently locks carbon dioxide, providing a stable long-term carbon dioxide storage solution. The process can even boost concrete strength by increasing the density of its pore structure. (CEMBUREAU 2020; Sanjuán et al 2020). See also Recarbonation". CEMBUREAU 2020. https://lowcarboneconomy.cembureau.eu/5-years-on/the-5c-approach/recarbonation/ Sanjuán, M.Á.; Andrade, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake by Cement-Based Materials: A Spanish Case Study. Appl. Sci. 2020, 10, 339. https://doi.org/10.3390/app10010339	Aniceto Zaragoza	Spain	Rejected. Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.
11233	0				Thre is not enough coverage of the mining sector and the role key minerals and the related investment and financing will play in the transition to a low-carbon economy. There is a paper on climate-smart mining from the World Bank, "Climate-Smart Mining: Minerals for Climate Action", which has not been considered. This follows the World Bank's 2017 report, “The Growing Role of Minerals and Metals for a Low Carbon Future”. https://www.worldbank.org/en/topic/extractiveindustries/brief/climate-smart-mining-minerals-for-climate-action	Ebenezer Arthur	Ghana	Noted. Thanks
11559	0	9	0	9	In Annex A: Glossary, page A - 9, after carbon stock definition, please add a new definition: "Carbonation Hydrated cement used in concrete or mortars naturally absorbs carbon dioxide during its lifetime, a physicochemical process known as carbonation, thus removing carbon from the atmosphere. This permanently locks carbon dioxide, providing a stable long-term carbon dioxide storage solution. The process can even boost concrete strength by increasing the density of its pore structure. (CEMBUREAU 2020; Sanjuán et al 2020; Andrade and Sanjuán 2018) See also Recarbonation". CEMBUREAU 2020. https://lowcarboneconomy.cembureau.eu/5-years-on/the-5c-approach/recarbonation/ Sanjuán, M.Á.; Andrade, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake by Cement-Based Materials: A Spanish Case Study. Appl. Sci. 2020, 10, 339. https://doi.org/10.3390/app10010339 Andrade C, Sanjuán MA. Updating Carbon Storage Capacity of Spanish Cements. Sustainability 2018;10:4806. https://doi.org/10.3390/su10124806	PEDRO MORA PERIS	Spain	Rejected. Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.
11709	0				The shortcoming of the metric GWP-100 for methane is recognized in the report and that other metrics, such as GWP* may better represent the actual warming caused by methane emissions. Still, the report concludes that GWP 100 shall be used but that "this choice does not constitute a recommendation to use GWP100 for any specific policy application as the most appropriate choice depends on the policy goal and implementation of the metric" (p26 1-3). While this might be a valid choice all things considered it becomes problematic when many of the conclusions in the report regarding food and agriculture are based on research using GWP 100, and that these conclusions are used for policy recommendations in the report. In particular, the results of lifecycle analysis for agriculture products and diets are heavily influenced by the metric used. The report concludes "rapidly declining CH4 emissions are given a negative CO2 -equivalent value based on GWP* but a positive CO2 -equivalent value based on GWP" (p 25, 25-27). In the case of diet scenarios this means, for example, that a diet with just a 10% reduction in ruminant meat or dairy will reduce warming using GWP* while using GWP 100 it still cause considerable warming. For further elaboration see John Lynch et al 2020 Environ. Res. Lett. 15 044023. This needs to be reflected in the texts about diets in chapter 7 and 12 (possible also in other places).	The Royal Swedish Academy of Agriculture and Forestry (Group Review)	Sweden	Taken into account in the revisions of Cross-Chapter Box 2.2 and supplementary material to chapter 2. Our assessment makes clear that GWP-100 does provide scientifically relevant information from a cost-benefit and cost-effectiveness perspective. Every tonne of methane emitted makes Earth warmer than it would be without that emission. Information provided in chapter 7 about abatement options for methane is therefore highly relevant from a mitigation perspective even if such mitigation results in less warming than previous emissions caused at a previous point in time, as indicated by GWP*. Chapters 7 reports emissions of individual gases, not only CO2-eq emissions, to increase transparency about abatement potential
11711	0				Agriculture is and can become an even bigger part of the solution. This is especially true for LU. This needs to be highlighted in the report. To increase that insight, the carbon cycle and soil carbon pools needs to be better described in future reports. Carbon sequestration is dependent on nitrogen supply. Although nitrogen gives rise to emissions it also is a prerequisite for using photosynthesis for increased carbon binding. Much of the carbon bound by agriculture is not made visible in the report. The carbon is also treated too standardized, not least taking into account what is stable carbon versus easily decomposable carbon. Stable carbon is protected in the soil. If the possibilities with photosynthesis are not highlighted, few outside the sector can understand how much of the potential available solution within AFOL: U. Within the EU, the sector is a net contributor with is a promising fact. Johnson, J.M.-F., Allmaras, R.R., Reicosky, D.C., 2006. Estimating source carbon from crop residues, roots and rhizodeposits using the national grain-yield database. Agron. J. 98, 622–636. Kätterer, T., Bolinder, M.A., Andrén, O., Kirchmann, H., Menichetti, L., 2011. Roots contribute more to refractory soil organic matter than above-ground crop residues, as revealed by a long-term field experiment. Agric. Ecosyst. Environ. 141, 184–192. Rasse, D.P., Rumpel, C., Dignac, M.-F., 2005. Is soil carbon mostly root carbon? Mechanisms for a specific stabilization. Plant Soil 269, 341–356.	The Royal Swedish Academy of Agriculture and Forestry (Group Review)	Sweden	Thank you for your comment. Noted. Revisions have been made in the final draft
11713	0				The report use the expression "plant-based diet". The term is poorly defined and therefore unscientific. It is often used in the meaning of food without animal products and could be understood as such (which was visible in media reports from the SRCCL). If it, instead, means a diet constituting predominantly plants it becomes meaningless as almost all people eat a diet where plants contributes most volume, weight and energy (global average is 18 % of calories from animal products). Diets needs to be regionalized.	The Royal Swedish Academy of Agriculture and Forestry (Group Review)	Sweden	Thank you for your comment. The report now uses "balanced, sustainable healthy diets" and provides a definition in the SPM

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14273	0	0	0	0	Luxembourg would like to thank the co-chairs the vice-chairs and the TSU of WG3 and in particular the authors for the present draft of the WG3 contribution to the AR6. We consider that report covers all the topics addressed in the outline and would like to encourage the authors to continue along these lines. We in particular acknowledge the difficult task of continue the work on the IPCC reports in period of COVID-19 pandemic and would like to express our sincere gratitude to all the people who are dedicating their time in producing the IPCC reports. We also would like to thank the co-chairs and authors to organize informal exchanges with the focal points or their alternates on the present draft of the SPM, to clarify the contents of certain concepts and figures. We would encourage having a similar exchange for the FGD too.	Government of Luxembourg	Luxembourg	Thank you for you positive comment
14275	0	0	0	0	We see the contributions of the different WGs to the AR6 as a continuation of the exploration of the findings presented in the three SRs that were already produce in this cycle and expect them to cover the open questions that were identified in these SRs. In addition, we expect the AR6 to present policymakers with the newest scientific findings published since these three SRs as well as the AR5.	Government of Luxembourg	Luxembourg	Noted, thanks
14277	0	0	0	0	We fully support the new structure of AR6 compared to AR5 being thematically structured. We recognize however, that this way of presenting the findings poses a particular challenge for the authors to remain consistent throughout the report and avoid duplicates. While we recognize the efforts to avoid this, we think there is still room to increase consistency and reduce redundancy through the report. This will in particular help to reduce the length of the SPM and the TS. We thus advice the authors to review, revise and shorten the report in order to further increase consistency and avoid duplication and will also give specific comments how to achieve this for the SPM.	Government of Luxembourg	Luxembourg	Noted. Report revised, also overlapping content removed where applicable
14279	0	0	0	0	While a regional perspective seems to be useful to illustrate some of the findings of the report, the approach to country groupings presented in Appendix B does not seem to be appropriate. Annex B seems to refer to the 1990 OECD countries, which is not up to date anymore. In addition, OECD countries do not cover all of the high-income countries. The assessment refers to classifications as in the UNFCCC Annexes. As the Paris Agreement does not use this classification anymore, the IPCC should not refer to it anymore. Finally, the classification of Annex B seems to include some overlaps of regions, in particular for Eastern Europe. For the final version of the report, we would prefer to see a classification based on criteria relevant to the analysis. These should include economic, technological, social and governance indicators that drive GHG emissions.	Government of Luxembourg	Luxembourg	Thank you for your comment . Text revised. We have revised the entire guidelines for regional classification for WGIII, as well as the text. The new text makes a clearer case for the adopted classification and the rationale behind it.
14897	0				Congratulations and heartfelt thanks to the WGIII Co-Chairs and the author team for providing a very promising SOD. All the hard work is even more appreciated in these difficult circumstances of the pandemic. More detailed feedback on the SPM and individual chapters is provided in the following comments, also regarding concerns related to the unique circumstances of most vulnerable countries like SIDS.	Government of Saint Kitts and Nevis	Saint Kitts and Nevis	Noted. Thanks
15157	0				The Chinese government appreciates and thanks the Bureau members, lead authors, and Technical Support Unit (TSU) of the Working Group III Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR6 WG III) for their painstaking efforts made for the preparation of the present report. In order to make WG III contribution a more scientific, comprehensive and balanced report, and fully consider the equity of the conclusions of the report, we wish to make the following comments which are hoped to be adopted. 1.Regarding the erroneous expressions concerning Chinese sovereignty. There are common-sense errors in the report regarding Taiwan Province and Hong Kong Special Administrative Region of China (including but not limited to page 98 of Chapter 2, page 244 of Chapter 5, pages 120 and 139 of Chapter 6, page 33 of Chapter 9, page 50 of Chapter 13, page 4 of Annex B and page 231 of Annex C),all these errors must be corrected. In some conclusions of the report, maps with national borders are used for the purpose of illustration, and there are also a number of errors such as different background colors for Taiwan Province and Chinese mainland in the maps, erroneous borderlines of East Section and West Section of China-India Border, omitting the Dotted Line of South China Sea as well as omitting the Diaoyu Dao and its affiliated islands. To avoid unnecessary disputes, it is suggested that WG III TSU replace all those maps with national borders in the report with maps without, and relevant figures must be redrawn based on national data to ensure that the same color is used for Taiwan Province and Chinese mainland in the maps, with island dots marked. For those studies with few samples, their analyses are suggested to be made in a textual or tabular form. The questionable maps include but are not limited to Figures 2.37, 6.13, 6.20, 7.12, Box 8.1 Figures 1 and 9.13. All these errors must be corrected in the hope that they will no longer appear in future reports. 2. Regarding the improper enumeration or insufficient presentation of Chinese examples. There are a large number of non-objective and unbalanced presentations involving China in the report, and an insufficient presentation of efforts made by China in taking action to mitigate and adapt to climate change. On page 19 of TS, for example, when discussing the reason that GHGs emission rate dropped in recent years, the Summary refers to a structural shift to gas in the United States and the increasing penetration of renewables in Europe, but neglects the fact that China is the world's largest new energy market, with the total wind and photovoltaic powers installations, installation increments and investment in new energy ranking first in the world for several years. The statement in Chapter 14 that the "complex and competing" identities of India and China have led to tensions in the negotiations, which is not factually borne out, should not be mentioned in a scientific report. Our specific comments are detailed in the table attached, which includes but is not limited to specific comments for the Chapters. It is suggested to further check and revise relevant statements. 3. Regarding the use of country classification criteria in the report. WG III report uses an improper country classification method, instead of the criteria used in previous IPCC assessment reports or prescribed in UNFCCC in this connection. In addition to the developed and developing countries, the report provides other categories such as emerging economies, and lists China individually in many places in the report, independent of any category (e.g. placing non-OECD Asia and China in parallel and ignoring the fact that non-OECD Asia includes China). These improper expressions include but are not limited to the specific comments for Chapters. It is hoped that the author team attaches	Government of China	China	Thank you for your comment . Text revised. We have revised the entire guidelines for regional classification for WGIII, as well as the text. The new text makes a clearer case for the adopted classification and the rationale behind it. Accepted. Language regarding land use efficiency has been revised. SOD Box 8.1, Figure 1 (map) has been deleted. We acknowledge that land use data on stocks versus changes show different trends, the author team feels both types of information are useful and necessary to include.
15743	0	0			Excellent work, extremely relevant, perfect timing. Congratulations to all the contributors!	Sara Budinis	France	Noted. Thanks
15749	0	0			I would suggest to refer as much as possible to recent literature. I know certain topics have not been covered in years, but COVID represented and is representing a major disruption and papers from 2014 or earlier may not be relevant anymore. This is particularly true when looking at the societal aspects of the energy transition, human behaviours, lifestyle changes etc.	Sara Budinis	France	Noted. Assessment is supposed to bring out agreement and disagreement in the literature. So, revised draft tried to best represent this. Also, the chapter conducted a systematic review which is also reported in the chapter.

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15777	0	0	0	0	All my comments are based on my professional skills (energy economics and climate economics related to energy economics). Thus they focus on these topics, mainly addressed in chapters 3, 4, 6 and 12 and summarized in TS and SPM. [continued below]	Jean-Michel Trochet	France	Noted. Thanks
15779	0	0	0	0	Concerning energy economics, the report is well documented. References are rich, including various dissenting analyses. References also include most updated analyses, such as International Energy Agency reports in 2019 and 2020 and other articles published in journals in 2020, notably concerning current and future costs of technologies for mitigation. As a result, my comments below can rely on the documents used by the report, including quantified analyses provided by IAMs. My main point is on the way they are used notably in chapter 6 and 12, and then summarized in these chapters and in the Technical Summary. [continued below]	Jean-Michel Trochet	France	Noted. No response needed.
15781	0	0	0	0	My positive assessment of references in energy economics may be contrasted with a less positive assessment concerning references related to Social Development Goals (SDG) issues. Here, references based on quantified analysis (positive and negative externalities in economic literature) are relatively incomplete. As a result, synthetic view on that matter, as it appears for example in TS table TS.10 page 133, is scientifically incomplete and as a result misleading. As mentioned above, I won't get into further details on that matter.	Jean-Michel Trochet	France	Noted.
16981	0				This is for Annexe A: We suggest adding to Annex A a definition for Nature's Contribution to People.	Government of France	France	Nature's contributions to people is defined in the glossary
19463	0				It would add clarity if the cut-off dates for literature could be clearly indicated. The policy environment will have changed by the time the report is published. While this of course is always the case, the assessment of (I)NDCs will lack behind the new set of NDCs that have, or will be, around.	Government of Sweden	Sweden	Thank you for your comment. The cut-off date has been added (11 October 2021) in the SPM and in the chapter
19617	0				The entire 6th assessment WG3 report addresses SRM (or particularly SAI) only once in a somewhat substantive manner, and there merely to discuss its risks. Given the consistency with which the modeling literature has found dedicated, limited SAI applications to limit change across climate variables and across regions this seems highly inadequate. There is an ever increasing body of such evidence and literature, which provides a differentiated light on possible up and downsides as a function of the form in which such application takes place. I suggest to substantially expand the scope of the cross-WG textbox in chapter 14 (p 51) to cover this literature with nuance.	Matthias Honegger	Germany	Noted. Thanks
19879	0				Given the importance of the accumulating empirical evidence on the effectiveness of the Kyoto Protocol since AR5 and absence of a consolidated assessment in WG III AR6 I would suggest to put a cross-chapter box on Kyoto Protocol effectiveness. It could be located in Ch. 14. Literature not yet covered in the report includes: Kim Y, Tanaka K, Matsuoka S (2020). Environmental and economic effectiveness of the Kyoto Protocol. PLoS ONE 15(7): e0236299.; Maamoun, N. (2019). The Kyoto protocol: Empirical evidence of a hidden success. Journal of Environmental Economics and Management, 95, 227-256; Miyamoto, M., & Takeuchi, K. (2019). Climate agreement and technology diffusion: Impact of the Kyoto Protocol on international patent applications for renewable energy technologies. Energy Policy, 129, 1331-1338; Grunewald, N. and I. Martinez-Zarzoso (2016). Did the Kyoto Protocol fail? An evaluation of the effect of the Kyoto Protocol on CO2 emissions, Environment and Development Economics 21, 1-22; Aichele, R. and Felbermayr, G. (2013). The Effect of the Kyoto Protocol on Carbon Emissions. J. Pol. Anal. Manage., 32: 731–757. Almer, C., & Winkler, R. (2017). Analyzing the effectiveness of international environmental policies: The case of the Kyoto Protocol. Journal of Environmental Economics and Management, 82, 125-151. Further, a bit older literature that could also be included in the assessment: Kumazawa, Risa, and Michael S. Callaghan. "The effect of the Kyoto Protocol on carbon dioxide emissions." Journal of Economics and Finance 36.1 (2012): 201-210, Halkos, G.E. & Tzeremes, Measuring the effect of Kyoto protocol agreement on countries' environmental efficiency in CO2 emissions: an application of conditional full frontiersN.G. J Prod Anal (2014) 41: 367. doi:10.1007/s11123-013-0343-1	Axel Michaelowa	Switzerland	Noted
20461	0				We would like to congratulate the authors on their work on this high quality report. We welcome the increasing attention given to social/societal aspects with a focus on the notion of « just transition », a new chapter "demand, services, and social aspects of mitigation" with a large part dedicated to social aspects and a close look to the link between mitigation issues and Sustainable Development Goals (SDGs). We recognize the clarity and policy relevance of the key messages, which are well referenced. The importance given to short-term decisions is very useful and relevant for the political context in which the report will be published. We also think that the consideration of the Covid 19 pandemic is useful.	Government of France	France	Thank you for your positive comment
20463	0				It seems that some figures, especially figures concerning GHG emissions, may not be very consistent between sub-chapters. It may be due to variations in the presentation and to different categorizations of GHG emission sources: figure SPM.8 where the food production sector is identified is for instance difficult to connect to the other figures, where it is encapsulated into the large AFOLU category.	Government of France	France	Thanks. Accepted. The revised figure changed substantially with cross chapter coordination.
20465	0				Please consider adding a definition on decoupling, in relation to GHG emissions and economic growth	Government of France	France	Noted. Thanks
20467	0				There seems to be a general thinking centered on farmers each harvesting large amounts of land, as now in most OECD countries, where these farmers do not represent more than 3% of the labour force. There is only one sentence in the report that reminds us that the majority of farmers in the world have less than 2 ha (p. 7-132). This micro-scale farming will remain in the future due to world land limits, population growth and "jobless growth" in non-farm sectors. But the perspectives and technologies considered in this report remain those of "large-scale industrial agriculture". Thus, we suggest that the report broadens its perspective from the rationalities of industrial agriculture.	Government of France	France	Noted. Thanks
20469	0				Please note that report of experiences in agroecology seem to be lacking, such as Natural Farming in Andhra Pradesh (http://apzbnf.in), most probably the world largest agroecological transition (Dorin 2021) Ref for "Dorin 2021" (forthcoming book chapter in French...) ; Dorin Bruno, 2021. "Théorie, pratique et enjeux de l'agroécologie en Inde", in Hubert Bernard, Couvet Denis (Dir.), La transition agroécologique. Quelles perspectives en France ?. Académie d'Agriculture de France. Presses des Mines. Paris.	Government of France	France	Noted - the report includes a substantive discussion on this topic in chapters 7 and12
20471	0				Please note this shortcoming: references to oceans and marine activities are generally missing, to the exception of fuel consumption reduction in shipping. This absence of marine uses is in great contrast with the dedicated focus of SROCC, and with WG II where oceans and coastal ecosystems has a dedicated chapter. The mentions are very little in comparison to the major roles that oceans play and will play in human activities, and the extent of scientific knowledge on these topics. Among the missing subjects are: renewable marine energies (offshore windmills etc) ; the role of fish and shellfish in low carbon diet ; the growth potential and the CO2 saving potential in aquaculture e.g. through more efficient feed and conversion rate ; the importance of sustainable fishing ; the role of carbon capture and storage of other marine and coastal ecosystems than saltmarches, mangroves, seagrass (for example, see the carbon storage of large whales. https://www.climateforesight.eu/oceans/whales-carbon-sequestration	Government of France	France	Noted - Marine ecosystems are considered in chapters 7 and 12 in relation to there role in mitigation

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20473	0				Please consider that as indigenous people come from very different communities, assessing how different their needs are and how their exposure to specific climatic and non-climatic issues differ could greatly help structuring this dimension of the report.	Government of France	France	Thank you. Noted
20475	0				It is suggested to include a broader perspective on multi-level governance, local, individual, community or local government experiences, short circuits, recycling, urban agriculture, etc. which are not present, even though they are one of the main drivers of mitigation and adaptation today. On the other hand, there is no analysis of industrial, agro-industrial modes of production, and current land use strategies for intensive agriculture, for example.	Government of France	France	Noted. Thanks
20477	0				Please consider mentioning the potential of education, and most notably university trainings, in influencing behaviours and raising awareness and capabilities to mitigate climate change.	Government of France	France	Thanks. Accepted. Included now in 5.4 supportyed by appropriate referencing.
20479	0				The report could perhaps use more homogenization regarding dates, references, figures and article numbers. As an example, Fig.6.1 (Chap6, p7) has a 2065 projection for "net-zero CO2 emission energy system" in nuclear that is not consistent with other figures from the report, such as Fig.3.16 (Chap3, p41), and other IPCC and IEA reports.	Government of France	France	Noted. We use a range of different scenarios to illustrate different points. There are many different pathways to net zero, and it's important that we present multiple perspectives.
20481	0				Please consider adding a definition on “sustainable intensification”.	Government of France	France	Accepted. There is a definition on 'Sustainable intensification (of agriculture)' in Annex I
20483	0				Please note that while the excessive consumption of meat is systematically presented as an emission factor, the responsibility held by the modes of production tends to be overlooked. Hence, the problems related to agricultural expansion for the cultivation of soybeans, palm oil, corn, etc. for intensive livestock production could probably be further underlined in proportionality. Indeed, meat can potentially be produced (and consumed) with low emission methods.	Government of France	France	Noted
20485	0				Please note that there seems to be an orientation of the report towards an occidental perspective, notably regarding technologies. Unidirectional cooperation and transfer of knowledge and technology appears to be favored. As an example, green roofs and green facades are an option in cold and temperate countries, but difficult to implement in Mediterranean or tropical countries.	Government of France	France	Noted.
20487	0				Please note that the bibliography appears to be overly centered on work that is written in English, which could be complemented by a more diverse peer-review literature, ideally sourced from a more representative list of world regions. As an example, The Experiences of Resilient Cities in Latin America are institutional publications, in Spanish, which could be included in the development of Chapter 8.	Government of France	France	Noted.
20505	0				In many places in the report, GHG emissions are expressed compared to a 2020 base year. This choice is not very relevant for the following reasons : (i) it is an estimated year, and not a historical one. It is highly unusual for IPCC reports to express variation in GHG emissions compared to an estimated year (ii) 2020 emissions are very specific due to COVID-19 crisis, and thus may confuse the reader when expressing a variation compared to 2020. We strongly advise the authors to use GHG data from the most recent historical year, be it 2019 or 2018.	Government of France	France	Noted. Thank you for your comment. The majority of the findings are now based on 2019 as a baseline, e.g. Table SPM.2.
20507	0				The report makes various references to the yellow vests movement in France. While some of them correctly reflect the complexity of this social protest, some other reference are over simplistic and present this movement as a mere protestation against carbon pricing, which is a misconception of the reality of the movement often conveyed by foreign media. We draw the attention of the authors on the fact that while the movement was indeed triggered by the increase of fossil fuel prices (to which the increase of the carbon tax was only one of the reasons - international prices also increased during that period), the various claims of that movement (which had no hierarchical structure) was much wider than carbon pricing : it was also about direct democracy, economic, social and geographical inequalities, etc. We made some comment in the SPM and in one chapter on that issue, but in a more general manner, we recommend that references to that movement do not oversimplify the reality by presenting it as a simple rejection of a carbon tax. By the way, the report makes no mention of the Citizen Assembly on climate change that was launched after the yellow vest movement, randomly picking a set of 150 citizens, representative of the diversity of the French society, which aimed at proposing a series of measures to reach France's GHG emissions targets. This is a unique experience of public participation to climate policy, and would deserve to be cited in the report. Since it is quite new, there are only few academic papers on the issue, but here a couple that can be used : https://www.iddri.org/en/publications-and-events/study/citizens-climate-convention-149-measures-new-vision-transition ;	Government of France	France	Accepted. Thank you. Revisions have been made.
28469	0				The report repeatedly cites literature which is not peer-reviewed and therefore do not adhere to academic/scientific standards. Reports by Material Economics, Energy Transitions Commission, SystemiQ cite their own previous work and sources in their report are either circular citations or untraceable sources. These authors tend to cite each other's work without transparently disclosing their modelling exercises. The same can be said about modelling exercises performed by the IEA, European Commission, and other political bodies. These sources are not scientifically robust and their results should be flagged as such, i.e. not taken at face value. In many cases the reduction shares for future scenarios are relative to their 'business as usual' scenarios, both of which do not follow established scientific modelling standards. As such, their claims should be hedged and put into correct perspective, i.e. compared to current emissions. Organisations such as the IEA, ETC and ME are not research institutions and their 'scenarios' should not be put en par with actual scientific modelling that undergoes a peer review process.	Mark Preston Aragones	Belgium	Noted
29451	0	0	0	0	To Entire report: Please conider to use colours consistent between figures throughout the document. We suggest that (A)FOLU is green throug the document and fossil fuels grey or black. And for reading by colour blinde people - don't place green and red colours next to each other.	Government of Norway	Norway	Noted
29627	0	0	0	0	Please scrutiny the report to make sure that it is not policy prescriptive, but policy relevant. In the technical chapters, the distinction between science-backed insight and policy recommendations based on that insight could be made clearer. The reader would then be able to more easily distinguish between what are facts and what are suggested lines of action for policymakers.	Government of Norway	Norway	Noted
29943	0	0	0	0	Please consider expressing "per year" as "/yr" instead of "yr-1" consistently through the report, as this might be more understandable for readers with a non-scientific background.	Government of Norway	Norway	Noted
29945	0	0	0	0	Please ensure that figures' resolution is high enough to be legible. This is particularly an issue in chapter 1.	Government of Norway	Norway	Noted, thanks. High resolution figures are added in the final version

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30327	0	0	0	0	We appreciate that the term "carbon sequestration" is not used in the SPM. However, in the rest of the report this term is used many times. In our view, this term is very challenging to understand for the reader. In general it is better to use language like carbon storage, uptake, or removal. Furthermore, the term carbon sequestration is not so suitable because it covers many very different options and these options have quite different characteristics. Therefore, it is better to list the options that are meant in the different parts of the report instead of using the very broad term carbon sequestration.	Government of Norway	Norway	Noted
30787	0	0	0	0	Overall, co-benefits and trade-offs between mitigation and sustainable development are well explained. However, the such relationships between mitigation and adaptation should also be described since they are closely related, including in balancing finances.	Government of Japan	Japan	Noted
31047	0				Military contributions to greenhouse gas emissions are missing from the report. This is a major weakness.	Daniel Helman	Micronesia, Federated States of	Noted
31085	0				The report itself is weak in presenting a coherent solution or family of solutions to the climate crisis. There ought to be a special chapter that presents a viable two year transition plan to zero anthropogenic carbon release, with several alternatives. It is unreasonable for the authors to assume that governments will be able to put this together themselves without a roadmap.	Daniel Helman	Micronesia, Federated States of	Noted
31105	0				The report does a poor job in presenting the pressing case for a new climate treaty. Under the Paris Agreement, the energy transition is too slow to prevent catastrophic results from climate change.	Daniel Helman	Micronesia, Federated States of	Noted - it is not the role of the IPCC to advocate for a new treaty
31417	0				We would like to thank the Co-Chairs and authors for their hard work, congratulations to a very impressive SOD! In the following, we will provide more specific comments on SPM and individual chapters on remaining concerns like overall readability and content issues like pathway classification, regional net-zero timings, and mitigation aspects particularly relevant to the Pacific region and SIDS.	Government of Palau	Palau	Thanks, noted
37593	0				(1) The report is placing technologies under development (called trickster technologies in the transition engineering literature) such as battery storage, various technology options related to carbon capture or removal etc. and well developed technologies such as nuclear on an equal footing, which is scientifically untenable. (2) It is necessary to take cognisance of water requirements for BECCS, which as per studies is likely to increase water stress (Please see Stenzel, F., Greve, P., Lucht, W., Tramberend, S., Wada, Y., & Gerten, D. (2021). Irrigation of biomass plantations may globally increase water stress more than climate change. Nature Communications 12 (1) e1512. 10.1038/s41467-021-21640-3.) (3) It is also necessary to indicate that increased penetration of intermittent sources will increase system cost. Not mentioning increase in system costs of intermittent sources with increase in penetration has created a false narrative about likely fall in electricity tariff. Fall in tariff has not happened anywhere. (4) The report shows a clear bias against nuclear. At several places, in place of "non-fossil fuels", the word "renewable" is used. As alternate one can use "renewable and nuclear". This is despite the fact that nuclear has been acknowledged as an established technology for example in Figure 3.43. (5) The concept of Energy Return Over Invested (EROI) and its implication in comparing different energy technologies have been ignored despite growing literature on the subject. For example, please see "Energy and the wealth of nations: An introduction to biophysical economics" by CAS Hall and K Klitgaard, Second edition, Springer, 2018. (6) At many places in the report, the word 'renewable' has been used, while one should us 'low-carbon' so that report remains technology neutral. In some chapters, such as chapter 4, this aspect is too prominent. Moreover, reference to 100% renewable option as propagated by Jacobson et al., 2017 should be either removed or accompanied by the fact that it has been rebutted for its methodological inconsistencies by (Clack et al, 2017, https://doi.org/10.1073/pnas.1610381114). (7) Nuclear science and engineering has applications beyond generation of electricity. Its applications include nuclear medicine, which is considered as the best modality for diagnosis by physicians. Application of radiation for cancer treatment is well acknowledged. It also has application in agriculture for development of mutant varieties of seeds, in research and industry (radiography etc.) Nuclear power plant can be co-located with hydrogen production facilities for the production of green hydrogen. It is ironical that none of these applications have been explicitly acknowledged.	Ravi B Grover	India	Noted. (1) These technologies are not on equal footing in Chapter 6. (2) Water requirements for CCS are discussed in Chapter 6. (3) Increased VRE penetration issues are discussed in Chapter 6. (4) Chapter 6 does not have a bias against nuclear, nor does it confuse renewables with low-carbon. (5) We have not focused on EROI in Chapter 6.
43701	0				We would like to thank the author team and the working group co-chairs for their work. While the draft already contains a valuable overview on several key aspects of mitigation, the assessment often remains generic. A more context- and region-specific assessment of mitigation options and feasibility would be appreciated. We also encourage the authors to more clearly communicate changes in methodology and results in comparison to previous reports, particularly the SR1.5. For instance, changes in pathway classifications should be further elaborated upon and justified.	Government of Jamaica	Jamaica	Noted. Chapter 3 has been completely revised and most of the issues raised here are now also being addressed.
45637	0	0	0	0	__Acknowledgement: We congratulate the author team on the excellent draft and express our sincere gratitude to the authors and all other experts involved in the preparation of this draft. We are extremely grateful for the enormous effort that has gone into producing this comprehensive scientific assessment of mitigation of climate change, in particular during these challenging times of a COVID-19 pandemic. We provide both detailed comments on individual statements and overarching comments on the overall draft. Comments have only been given once, even if they are relevant to an underlying chapter, the TS and the SPM.	Government of Germany	Germany	Thank you for your positive comment
45639	0	0	0	0	__Changes compared to previous reports: Please highlight substantial changes compared to IPCC AR5 and/or SR1.5, in particular with regards to information about timing of net-zero emissions, remaining emission budgets and peak years. E.g., please explain why WG I SOD states that 1.5°C warming will be reached 10 years earlier than in the SR1.5 but WG III indicates that the timing of net zero CO2 will happen 5 years later than in the SR1.5. Please elaborate also on the changes of the remaining carbon budgets and the relation between the numbers provided in WG I and WG III. Please also provide background information for what reasons these changes occur, including the consequences for the WG III assessment resulting from the changes in the historical temperature record and the ECS in WG I in relation to previous IPCC reports and the Paris Agreement's temperature targets.	Government of Germany	Germany	Noted, thanks

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45641	0	0	0	0	__Country groupings: We have serious concerns about the approach to country groupings presented in Appendix B. The three nested levels of country groupings used as the basis for the assessment and the additional groupings used in the report are not suitable to provide relevant information. We therefore urge the authors to revise their approaches to country grouping. - The high-level classification of developed countries seems to refer to the 1990 OECD countries, i.e., most members belong to the high per capita income countries, but in 1991 the OECD had eight fewer countries than today. Moreover, several high-income countries are not members of the OECD, but should belong to the group of developed countries (High Level). - The three classification levels are not consistent with each other, e.g., Eastern Europe (Low Level) is part of the developed countries (High Level), but at the same time Eastern Europe is also a classification (High Level) within the group of developed countries (High Level). - Comparing the information on High Level and Low Level, it turns out that some countries with a high HDI and a high GDP are not in the group of developed countries. On the other hand, some countries with lower income levels are allocated to the group of developed countries. - Part of the assessment of WG III refers to classifications from the UNFCCC Annexes, which represent the levels of development in 1992, and are therefore no longer valid. The Paris Agreement no longer refers to Annex 1 and non-Annex 1 countries, but to the principle of "common but differentiated responsibilities and respective capabilities". This reflects that the old classification from 1992 is no longer seen as helpful. We are concerned that these classifications lump together countries with very different levels of economic, technical and human development. We do not see a systematic and scientific approach for the choice of country classifications. We kindly urge the authors to provide alternative approaches to country groupings based on criteria relevant to the analysis of the WG III report, including economic, technological, social and governance indicators that drive GHG emissions as well as the availability and implementation of mitigation options. In addition, each time when using these classifications for country groupings in the report, please refer to the explanations in Annex B since understanding the approach underlying the country groupings is essential for understanding the information provided.	Government of Germany	Germany	Thank you for your comment . Text revised. We have revised the entire guidelines for regional classification for WGIII, as well as the text. The new text makes a clearer case for the adopted classification and the rationale behind it.
45643	0	0	0	0	__Provision of most updated information on mitigation plans: The current draft's NDC estimates are based on the first round of submission to the UNFCCC and do not include recent updates. For the future drafts of the report, we kindly request the authors to include all forthcoming submissions that are available by the finishing of the final draft, and to provide an updated assessment on what this means for achieving the goals of the Paris Agreement. Please also consider to include climate policy announcements by countries (other than NDCs) into this aggregated analysis. Please provide transparent information which NDCs or other announcements have been included in the analysis (cut-off dates). This also applies to terms such as "current policies". Please be more explicit what "current policies" comprise and until what date policies (announcements) were considered.	Government of Germany	Germany	Thank you for your comment. Noted. The NDC cut -off date (11 October 2021) is mentioned in the report.
45645	0	0	0	0	__Understanding of scenarios and pathways: We appreciate the detailed explanations in Annex C on scenarios and models that contributed to the knowledge basis of this report. We also welcome the introduction of a set of illustrative pathways and use of categorized emission pathways, including those categorized by warming levels (C1-C7). To further improve the report, we have some suggestions as to the choice, criteria, names and information provided. - Please elaborate on the effect of the estimated scales of NET on highly policy relevant quantities like the timing of net zero, remaining C-budget, peak temperature, and provide information on how these quantities change with different assumptions on NET. Please see also our comment on Table SPM.1 with more detailed suggestions regarding the information on the emission pathways categorised on their temperature outcomes (C1-C7). - Please make sure to provide consistent numbers for CO2/GHG mission reduction levels to achieve certain temperature targets. For net-zero targets, please specify whether this entails a linear or rather a long tail progression. Net-zero dates without this information could be misleading with regards to the required mitigation effort. - Please explain why WG III did not choose Illustrative Pathways that are consistent with the CMIP6 projections assessed by WG I, since this would have been most useful for policy makers, and probably would be beneficial for the SYR. Please provide information on the relation between the C- and IP-pathways and the RCPs. - Please clarify the difference between the IPs and the C-scenarios in the SPM to avoid confusion. An additional table might be useful. - Please choose names for the IPs that are more systematic (always refer to the warming level) and self-explaining, in particular change "Sup" to "OS", analogous to “NBZ” reflecting that this is an overshoot pathway. - Please describe the difference of "pathway" and "scenario" since these are often used interchangeably, e.g., "overshoot scenarios" and "overshoot pathway", or for 1.5°C, low carbon, or RCP and SSP which are both pathways and scenarios. Also, please define "development scenario/pathway". It would be very useful if the IPCC could come up with clear definitions of these terms and use them consistently across the	Government of Germany	Germany	Noted. Chapter 3 has been completely revised and most of the issues raised here are now also being addressed.

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45647	0	0	0	0	__Integrated Assessment Models: IAMs are of key importance to the WG III assessment, but the current draft is often silent on their characteristics and limitations. Ch3 p. 17 states: “IAMs can provide very useful information, but this information needs to be carefully interpreted and integrated with other quantitative and qualitative inputs in the decision-making process.” To enable policy makers to adequately interpret IAM results, more transparency on model characteristics and limitations is needed across the report in the chapters and the ES, not only in Annex B. We strongly suggest including a detailed box in the TS and smaller one in the SPM with key characteristics, limitations and possible applications of IAMs to provide guidance to policy makers on the usage of information from IAMs on mitigation pathways, including timing of net zero, interim targets and budgets, including the effect of the estimated scales of NET on these highly policy relevant quantities. Please inform about topics such as the economic paradigm, discount rates and their implications (including intergenerational justice, timing of action); the caveats and omissions of cost-benefit analysis, the lack of consideration of the benefits of avoided climate impacts (especially in overshoot scenarios) and the co-benefits of mitigation; the focus on techno-economic processes and the inability to represent social/multi-actor governance aspects and political economy of delayed action (e.g., resistance of interest groups); the consequences of outdated information on potentials, baseline scenarios and costs of renewable energy options; the poor representation of demand side options and distributional aspects; the consequences for the cost-optimal consideration of CDR without taking into account feasibility and sustainability constraints, leading to unrealistically high deployment rates of CDR/NET and possibly preventing/delaying mitigation action (mitigation deterrence effects); inability to consider socio-technological discontinuities; value judgement influencing the scenario design; the asymmetry of the Earth system response to emissions and removals (WG I SOD Ch 5); the consequences of cost optimization ending in 2100 (ignoring follow-up costs of e.g. large CDR infrastructures) and ethical considerations of IAMs. Please clarify about the possibility that even when many models come to the same result, this does not necessarily mean that the result is correct. This assessment might be misleading since models and research communities are not independent. Please revise your confidence statements across the report that often seem to imply that high model agreement is associated with high confidence in the result. Furthermore, please clarify different types of IAMs, e.g., approaches differing in what is used as input data and what is obtained from the model runs, to enable the reader to distinguish between different budgets and different approaches throughout the report.	Government of Germany	Germany	Noted. Chapter 3 has been completely revised and most of the issues raised here are now also being addressed.
45649	0	0	0	0	__BECCS: Although the report mentions some sustainability issues of BECCS, we urge the authors to present a more balanced assessment of these issues and provide an overview of the potentials and risks as well as uncertainties of specific BECCS options and the upstream sources of biomass (energy crops, by-products etc.). A comprehensive scientific assessment by the IPCC should not only refer to findings from natural sciences and technology, but also address the socioeconomic context (like energy balance, mitigation deterrence, acceptance or land use conflicts) in order to avoid a misrepresentation of BECCS. The presentation of BECCS options appears to be too optimistic, especially when considering the low removal potential of BECCS discussed in recent findings, e.g., WG III ch. 6 p. 43. In addition, contradictory interpretations of the technologies’ risks and impacts can be found across chapters. Moreover, some of the numbers (e.g., ch.12 p.35) about BECCS are (implicitly or explicitly) framed as scientific findings although they are only concepts or model requirements to achieve certain climate policy targets. This should be clearly indicated. Beyond the dynamics of uncertainty in BE and CCS, we kindly ask the authors to discuss essential open questions regarding effects of changes to the carbon cycle (Zickfeld, 2015 & 2018), as would be caused by large-scale negative emissions. Recent research suggests that these have the potential to negate some of the desired effects (Tokarska and Zickfeld, 2015, https://doi.org/10.1088/1748-9326/10/9/094013; Zickfeld et al.,	Government of Germany	Germany	Noted, thanks
45651	0	0	0	0	__Assessment of CDR options: A precise and common understanding of scientific terms and a clear distinction between them is crucial for the scientific discourse. Hence, we kindly urge the authors to clearly differentiate between activities and measures for emission reductions or avoided destruction of natural carbon reservoirs on the one hand and carbon dioxide removals on the other. Especially, please return to the previous definitions of CDR and mitigation in the AR5 and in the SR1.5 and refrain from combining both categories under the umbrella of mitigation. Such a combination would not reflect their different characteristics, e. g. role and importance for climate action, technological readiness, impacts on the environment and society, as well as uncertainties and risks. We urge the authors to provide a more balanced consideration of different CDR options in the mitigation pathways from IAMs, refraining from – or at least being transparent when – using overoptimistic (i. e., neglecting sustainability and feasibility constrains) estimates of large-scale deployment in particular in the second half of the century and reflecting sustainability implications and constraints (see also Creutzig et al.; 2021, https://doi.org/10.1111/gcbb.12798, please see also our comments on the Entire Report on IAMs and on BECCS). In addition, please amend the definition of carbon dioxide removal as to explicitly include the enhancement of biological sinks through anthropogenic activities such as restoration and management of ecosystems. Further, please make sure to use the term “nature-based solutions” only when its meaning in the sense of the definition in Annex A is intended (see examples for imprecise use in our comments on Ch 7.6.4.3).	Government of Germany	Germany	Noted. Thank you for your comment. A startiing point in WGIII report would be Ch12 (cross sectoral issues), section 12.3. At the beginning of the section, there is a cross chapter box on CDR which sets out the taxonomy, of CDR methods, used in the report. Ch3 (Long term emission reduction pathways), Table 3.5 has some summary stats of the amount of CDR used in the scenarios and by methods. There are also more stuff in Ch6 (energy systems) and Ch7 (AFOLU)

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45653	0	0	0	0	__Assessment of potentials, risks and feasibility of technologies: The assessment of the role of specific technological mitigation options for climate mitigation is an essential element of the WG III report. We appreciate the information provided about the various potentials, risks and feasibilities. However, we have serious concerns that the IPCC does not provide a fully balanced and complete assessment in some areas. The partial neglect of risks and of criteria that determine mitigation potentials beyond purely technological aspects can lead to an overly positive assessment. Feasibility assessments are methodologically challenging and should not be condensed too much to avoid misinterpretation and biases. We therefore strongly encourage the authors to enhance the assessment of technology risks. This includes the risk assessment of CCS including the quasi-permanence of storage and the risks of leakage. Furthermore, please take into account the risks of nuclear energy, including nuclear waste, hazard and other security issues. The current draft often implies that there is only a public perception of risks from CCS and nuclear energy that are non-existent in reality. Please see also our comments on the Entire Report regarding the assessment of CDR and BECCS. Second, while we appreciate the assessments of sectoral mitigation potentials, we are not convinced that the approach to cross sectoral mitigation potentials matches the high-quality standards of the IPCC. Cross sectoral mitigation potentials have been criticised for not being scientifically robust and were not included in AR5. The current draft introduces four types of potentials (technological, economic, sustainable, feasible) that are partly overlapping. Chapter 12 reports cross sectoral potential as economic potential (the portion of the technical potential to GHG reductions relative to baselines, for which social benefits exceed social costs, taking into account a social discount rate and the value of externalities - here only related to GHG emissions). This definition is unclear and the underlying assumptions are not transparent. This includes the following issues: inconsistent baselines across sectors and assessed studies; limited knowledge about social benefits and costs, the discount rate being a value judgement; vague and incomplete consideration of the values of externalities. It also remains unclear how interactions between sectors and the temporal evolution of cross sectorial mitigation potentials have been assessed, and how accounting for sustainability and feasibility aspects would affect the results. We therefore suggest a thorough revision of this section improving the explanation of the methods and assumptions, and to provide more robust and realistic information on the cross sectoral mitigation potentials, including sustainability and feasibility considerations. Third, we highly appreciate the efforts to provide feasibility assessments, but more guidance is needed on their information content und the robustness of the information. For example, the assessment does not use the same indicators across chapters, and it is unclear how the feasibility scores of sector-specific and cross sectoral indicators have been obtained (e.g., for which time and period, context, feedbacks) and how the diversity of approaches in the assessed literature has been addressed. Furthermore, the additional condensation of the feasibility assessments for the various dimensions per sector in figure SPM.10 levels out all interesting information so that the assessment is not useful anymore. The assessment of feasibility challenges for different timings of policy action (also figure SPM.10) seems to be strongly dependent on assumptions in the IAMS, including the discount rate as well as the availability and costs of CDR options. We do not consider such information	Government of Germany	Germany	Noted. Thank you for your comment. We expanded in the feasibility assessment to capture these issues consistently with the availabel underlying literature.
45655	0	0	0	0	__Information on sectoral mitigation potentials and pathways: We welcome the provision of information in the SPM regarding the role of individual sectors to limit global warming below 2°C/1.5°C. Please be as specific as possible (e.g., net-zero timelines and interim targets, efficiency of mitigation options), if the scientific robustness of these sector-specific information can be warranted.	Government of Germany	Germany	Noted. Thank you for your comment. The report reflects the limitations of IAMs in various sections including: SPM, Chapter 2, Chapter 12 (on CDR) and Annex III. Other chapters highlight these limitations too where appropriate. This is not only applicable to IAMs, but also to all various methods used
45657	0	0	0	0	Glossary, Annex A: Please add the definition of "land" used in this report to the glossary.	Government of Germany	Germany	Accepted. Thank you for your comment
45659	0	0	0	0	Glossary, Annex A: The term "gender responsive" (as used in TS, p. 126 line 43) should be included in the glossary and defined .	Government of Germany	Germany	Rejected. Thank you for your comment. While an important concept, this would be better explored in depth in the chapters rather than added as a glossary entry.
46435	0	0			We strongly encourage authors not to provide lists of research needs (e.g. Ch 13), as this can be seen as a conflict of interest and policy prescriptive. Please also avoid formulations requesting specific research topics, such as "we need more research", "is required". When describing "knowledge gaps" please keep in mind that a non-scientific audience might have a different perception of this term. Being as specific as possible might help avoiding misinterpretation of comprehensive ignorance or even a fundamental lack of knowledge. To this end, renaming the sections "knowledge gaps" to "open questions" might be beneficial.	Government of Germany	Germany	Noted
46437	0	0	0	0	A large part of the AR6 WG II report is framed around climate resilient development pathways. It would be very useful if the WG III report would also refer to this framing.	Government of Germany	Germany	Noted. Thank you for your comment. WG III focuses on the mitigation of climate change and the authors stick to the approved outline. Climate resilient development pathways is in the approved outline of WGII but not in WGIII
46439	0	0			We are very concerned that may figures are blurred or even placeholders. Figures are particularly important and should be reviewed by experts and governments.	Government of Germany	Germany	Thank you for your comment. Noted

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46441	0	0			As overarching comment: CH3, p14, describes as the two main characteristics of the various scenarios (1) emission reduction and avoidance (2) Carbon Dioxide Removal. There are substantial differences between these two characteristics, and consequently previous IPCC reports have treated them as separate response options, with the first one generally termed "mitigation" (We strongly recommend to keep this clear separation.) Consequently, it should be a key feature in this report to look at the interdependence of these two ways to respond to climate change AND to analyse as thorough as possible if and how the analytical approaches used throughout this report may influence the partitioning among these two regimes. Yet, by treating CDR as just another mitigation method and also hybrid CDR methods (which are biomass-based, but not exclusively nature-based) are included in the AFOLU, the discussions of these key decision points are distributed over several sub-section and are overall underrepresented or not visible enough, given its high importance.	Government of Germany	Germany	Noted. Chapter 3 has been completely revised and most of the issues raised here are now also being addressed.
46443	0	0	0	0	The limitations and recent development trends of IAMs should be stated more prominently across the report, not only in Annex C. As the models are of key importance to the WGIII assessment, model characteristics and limitations should please also be incorporated into the TS and the SPM. Additionally, it should be clarified that even when a large number of models come to the same result, this does not mean that this result is correct. However, at many occasions in the report, high model agreement is associated with high confidence in the result. This assessment might be misleading since these models and the research communities creating them are not independent. Sometimes, in a specific area more recent but few models yield more realistic results. Furthermore, not all models are suitable to inform climate policy measures as highlighted in Annex C, especially in the last paragraph of Annex C, Section I.9.5 on page 29. Ill-informed decisions might even have been taken from flawed modelling in the past. One important example is the large reliance on BECCS in many models/scenarios, simply because other CDR options have not yet been fully explored or are not covered at all (see Chapter 12.3). Hence, calling for deeper BECCS implementation based on such models is not reasonable.	Government of Germany	Germany	Noted. Thank you for your comment. The report reflects the limitations of IAMs in various sections including: SPM, Chapter 2, Chapter 12 (on CDR) and Annex III. Other chapters highlight these limitations too where appropriate. This is not only applicable to IAMs, but also to all various methods used.
46445	0	0	0	0	The presentation of BECCS options seem to be far too prominent in several chapters, with regard to the low to non-existent mitigation potential that BECCS has in recent findings - some of which are cited in the WGIII report itself (e.g. chapter 6 p. 43). In and between chapters, contradictory interpretation of the technologies' risks and impacts can be found. On both sides of the BECCS-concept (BE & CCS), conflicts around inherent uncertainties and perceived levels of acceptable risk therein appear to have led to an unbalanced political framing beyond displaying the state of science. In this, extreme assumptions of technical potential anchored in extremely ambitious prerequisites play an ambiguous role. Yet, they dominate most scenarios analysed. Given globally increasing damages and losses to essential ecosystem services not least through measures within the AFOLU sector, we think that many of these prerequisites to claimed potential rather bear risk contributing to further destruction then being part of sustainable solutions. For instance, the increased water demand for irrigation is only one of many problems. Some of the numbers (e.g. chapter 12 p. 35) about BECCS are (implicitly or explicitly) framed as scientific findings although they are only concepts or requirements to achieve climate policy targets. Beyond dynamics of uncertainty in BE and CCS we like to hint to essential open questions regarding effects of changes to the carbon cycle (Zickfeld, 2015 & 2018) as would be caused by large-scale negative emissions. Research suggests these have potential to void portions of the positive effects hoped for. (Tokarska K B and Zickfeld K 2015: The effectiveness of net negative carbon dioxide emissions in reversing anthropogenic climate; https://doi.org/10.1088/1748-9326/10/9/094013; Zickfeld K, MacDougall A H and Matthews H D 2016: On the proportionality between global temperature change and cumulative CO2 emissions during periods of net negative CO2 emissions	Government of Germany	Germany	The report includes extensive discussion on BECCS in Chapters 7 and 12
46447	0	0			Please rephrase all policy prescriptive formulations across the report, including "needs to be implemented", "is required", "must combine", "are essential" and more. It is essential that the IPCC remains neutral in order to maintain its credibility and authority.	Government of Germany	Germany	Noted. Thank you for your comment.
46449	0	0			It is well received that the draft has improved considerably since the FOD. However, some problems arising from the inability of bookkeeping and IA models to capture sub-scale changes in e.g. management, still remain and should be addressed more up-front. For example, this complicates cross-sectoral assessments of biomass flows and leads to over- or underestimation of potentials, costs, trade-offs, etc.	Government of Germany	Germany	Noted - this has been addressed in chapters 7 and 12
46451	0	0	0	0	Please do not mix LULUCF and AFOLU. At various places in the report, reference is made to e.g. "forestry and other land-use change" or other "mixed", not readily attributable forms. The first example is just plain wrong by definition (forestry is land management, not a change in its use). In the concept of AFOLU land-use change is incorporated and not named separately. On the other hand, e.g., "Forestry and other land-use change", if taken from the LULUCF context, excludes emissions related to land-use, be it deliberately or not. This comment may look like nit-picking, but not getting the basics straight raises doubt and concerns about the analyses based hereon, and also about the competence of the authors - you do not want this, I assume.	Government of Germany	Germany	Thank you for your comment. Noted and revised
46453	0	0			Glossary: please include an entry on "shifting development pathways to increased sustainability (SDPS)"	Government of Germany	Germany	Thank you for your comment. In the Glossary, a definition of Shifting development pathways to sustainability is added
46455	0	0			The AR6 WGI assessment has estimated a remaining carbon budget from 2020 onwards, whereas in the WGIII-SPM (paragraph C2.1.) the budget is "from the year 2019". Different values are also given for the annual CO2 emissions which are estimated to have reached 43+-4.1 GTCO2/yr "at the 2018 rates" (e.g. TS-3-17, line 14, and Ch. 2.2.2.1, page 2-29, line 12) against 43+-2 GtCO2/y in 2019 (e.g. Chapter 3.5.1, page 3-63, line 10) and 42 GtCO2 in WGI-SOD. Please update to final estimate throughout the report in order to ensure consistency across the AR6, as the annual CO2 emissions have a direct impact on the number of years in which the budgets will be exhausted, estimated in WGIII.	Government of Germany	Germany	Reject. Thank you for your comment. WGIII estimates, and uses where relevant, cumulative CO2 emissions until net zero CO2, which are different from the Remaining Carbon Budget. This is discussed in detail in Chapter 3. Some sections of the report use the Remaining Carbon Budgets

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47157	0				As Net zero targets become a focal point of the discussion and a main issue, the exact definition of net zero becomes relevant.	Stuart Minchin	Australia	Thank you for your comment. Two definitions are in Annex I: Net zero CO2 emissions; Net zero greenhouse gas emissions
47397	0				Thank you very much to WGIII Co-Chairs and authors for preparing a SOD and SPM FOD that are in good shape overall. We are grateful for all the work that has been put into these draft documents, especially given the very challenging circumstances of the COVID-19 pandemic. Several improvements with regard to WGIII AR5, in particular efforts to ensure cross-WG consistency are highly appreciated. More specific comments on SPM and individual chapters will be provided in the following.	Government of Saint Lucia	Saint Lucia	Noted. Thanks
47579	0				Thank you to WGIII Co-Chairs and authors for preparing a SOD and SPM FOD that are in good shape overall. I would grateful for all the work that has been put into these draft documents, especially given the very challenging circumstances of the COVID-19 pandemic. Several improvements with regard to WGIII AR5, in particular efforts to ensure cross-WG consistency are highly appreciated.	Benise Joseph	Saint Lucia	Thank you for the postive comment
60119	0				In order to have balanced view on the effectiveness of all advanced technologies for planning mitigation pathways, the potential of nuclear may be brought our more quantitatively.	Umasankari Kannan	India	Noted. Nuclear is addressed in Chapter 6
60121	0				For example the potential of SMRs to replace fossil fuel palnts has been quantified (IAEA workshop on Future of Low Carbon energy systems - July 2019)	Umasankari Kannan	India	Noted. Thanks
60123	0				It is imperative that for large scale reduction in carbon foorprint and control of GHG emissions, Nuclear energy has potential in the near term as designs are already deployable. The report should give focus on these pathways. It seems to be lacking in this aspect.	Umasankari Kannan	India	Noted. Nuclear is addressed in Chapter 6
60125	0				The offshoot benefits of nuclear energy are enormous, The non power applications in medicine and agriculture has been firmly established. The indictors and drivers will have to factor the multi uses of nuclear energy. This singular aspect will drive Nuclear as potential near term option for no carbon or even factor in reduction in the cost estimations while calculating tariffs.	Umasankari Kannan	India	Noted. Nuclear is addressed in Chapter 6
60169	0	0	0	0	Geographical references should be used in a clear and consistent manner throughtout the report preferably in line with with previous WG3 reports. The reference to "Eurasia" as a misleading geographic term should be avoided or its scope clearly defined within each section of the report (including the SPM).	Government of Hungary	Hungary	Noted. Thank you for your comment. Regional classification is now consistenly used in the report.
61089	0	0	0	0	Expression of the term 'FFI' is inconsistat. Fossil fuel and industry (SPM-5, TS3-14), fossil fuel combustion and industrial processes (SPM-6, TS3-14, 1-14, 2-11, 2-27, 2-28), fossil fuels and industrial processes (2-12), fuel and industry (2-71), Fossil Fuel Industry (2-4, 2-107). No standard definition of the term has been provided. Please clearly explain what is included in FFI e.g. does it include Fuel combustion activities within Energy sector along with IPPU sector?	LOKESH CHANDRA DUBE	India	Thank you for your comment. Revised
61933	0				The entire report uses the word "renewable" in places where the term “low-carbon” would be scientifically more accurate, more inclusive and relevant for climate mitigation and emissions reductions and much more technology neutral. The use of “renewable” when in fact “low-carbon” should be used is rather widespread in overall policy discussion, in both peer-reviewed papers and in mainstream media-articles, and even in policy measures. This leads to suboptimal outcomes, and should be something that technology neutral and science-based bodies like the IPCC does not enforce, but seeks to correct. A thorough analysis of why the term "renewable" should be substituted with "low-carbon" is available at (Harjanne and Korhonen, 2018, https doi org/10 1016/j enpol 2018 12 029). 1/8	Rauli Partanen	Finland	Noted. Chapter 6 does not confuse low-carbon with renewables.
61935	0				The report contains a lot of research and scenarios that are not technology neutral, and the most significant of these is the a priori exclusion of nuclear energy's techno-economic potential from the roadmaps and scenarios discussed. One example is Chapter 12 discussion on direct air capture of carbon, where cited research (Breyer et al., 2019a; Breyer et al., 2019b) concludes that "[a] common misperception is that excess electricity of a few hundreds of hours per year from solar or wind plants could be used for DAC, but detailed cost analyses show least cost of captured CO2 at 6000-8000 full load h[ours] per year, which requires a constant energy supply incompatible with the previous notion of only excess electricity utilization" and that "It should be noted that a constraint has been applied to block new fossil fuel and nuclear power installations after 2015." This, even though reliable nuclear technology would be precisely what would be needed for low-cost DAC. 2/8	Rauli Partanen	Finland	Noted. Chapter 6 reviews a broad literature on scenarios, many of which have substantial nuclear power.
61937	0				A good example of the effects of having technology neutral scenarios vs. scenarios that a priori exclude nuclear is from US DoE report (Nelson et al., 2014, https://doi.org/10.2172/1163655) which investigates deep decarbonization scenarios for western North America and California electricity grids. One of the 16 scenarios is “technology neutral” to (citation from the authors): “The purpose of the New Nuclear Scenario is to compare on a level playing field the cost of decarbonization via nuclear power relative to renewable and/or CCS options.” As can be seen in figures 3.4 and 3.10 of (Nelson et al., 2014), the unconstrained scenario has a much higher share of nuclear than the constrained ones and also comes at significantly lower overall cost. This important information is not communicated to policymakers if nuclear is constrained in all of the scenarios, one way or the other. 3/8	Rauli Partanen	Finland	Noted. No response required.
61939	0				Another omission is made in Chapter 6 regarding low-carbon hydrogen production, where the cited research (Graves et al., 2011; Kayfeci et al., 2019) stresses the importance of high capacity factor and concludes nuclear to be significantly more economical in hydrogen production than the wind and solar that are strongly promoted in the current draft, e.g., in Figure 6.1. In addition, as very large amounts of hydrogen are needed to decarbonize energy use that can’t be readily electrified, the discussion should focus more on this scale than using electrolysers to handle the overproduction of variable renewables at higher penetration levels, as this is much too small a sector to make significant dent in the fuels used in industry, heating and long-distance transportation. 4/8	Rauli Partanen	Finland	Noted. Chapter 6 mentions the use of nuclear for hydrogen production.
61941	0				This all creates a self-enforcing feedback-loop. No proper representation for nuclear in major reports such as IPCC AR6 leads to nuclear not discussed as a potential tool, and policy that could enable it to participate fully in climate mitigation fails to emerge, leading to a suboptimal outcome of nuclear energy playing a much smaller role than it could and a higher risk for failure in mitigating climate change both on time, at lowest risk and cost possible, and at the scale needed. It is not the role of IPCC to enforce current policies and people’s misperceptions, especially if they are suboptimal for climate and environmental point of view, but to present the pathways forward in as technology agnostic and neutral way as possible. Changing discussion from “renewables” focus into “low-carbon” focus and including nuclear technology in the discussion as the relevant choice it is, would go a long way. 5/8	Rauli Partanen	Finland	Noted. Chapter 6 has an extensive discussion of nuclear power.

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61943	0				The tone in which nuclear is discussed also seems needlessly negative in many places, compared with renewable energy discussion tone. This also shows in what is even discussed and presented. One example is the illustrated pathway scenarios <2-Ren and 1.5-Ren that explore "enhanced development and rapid diffusion of renewables" but there is no comparable illustrative pathway that would explore similar assumptions for nuclear. Yet Chapter 3 suggests that "also nuclear power can be part of a mitigation strategy, although its contribution does not reach more than around 20% of total TPES even in high-nuclear scenarios (see also Berger et al. (2017))." The mentioned study (Berger et al., 2017) describes a scenario where nuclear would provide up to 20 TWe capacity by 2100, completely pushing fossil sources out of the energy mix and being compatible with IPCC climate targets. This shouldn't be dismissed by an offhand "see also…" but perhaps presented as one possible "high nuclear" Illustrative Pathway scenario. 6/8	Rauli Partanen	Finland	Noted. From Chapter 6, we disagree. Nuclear is clearly highlighted as an important low-carbon option.
61945	0				It would also be prudent to have scenarios that see historical trends of growth in final/primary energy use continue – and the needed scale of decarbonization action for example in the energy sector. Relying overly much in efficiency improvements as a tool to decrease emissions is unproven, as efficiency gains often lead to rebound and further economic (and energy use) growth. If all we see are scenarios that have relatively low energy usage in the future, policy makers and societies in general will fail to prepare for scenarios where energy demand keeps on growing as it has, as developing world expands both in population and in economic activity per person in the coming decades (which will, in turn, increase their chances of adapting to climate change and its effects). These scenarios need to be included to give a more robust awareness of the possible future and needed scale of operations. 7/8	Rauli Partanen	Finland	Noted. Chapter 6 does not focus exclusively on demand-reduction focused strategies
61947	0				Finally, as pointed out in my comments in the relevant chapters, the evaluation of nuclear energy in regards to Sustainable Development Goals (SDGs) needs to be redone in light of the publications mentioned below: UNECE 2021 "Use of Nuclear Fuel Resources for Sustainable Development – Entry Pathways" (https://unece.org/sustainable-energy/publications/nuclear-entry-pathways) publication provides valuable guidance that previously was unavailable, as does the earlier publicatoin by IAEA (https://www.iaea.org/bulletin/57-3 and https://www.iaea.org/sites/default/files/bull573sept2016.pdf). It now seems very much negatively biased against nuclear. 8/8	Rauli Partanen	Finland	Thank you for the comment. These are carefully checked and revised. (For e.g., see Figure SPM.8)
63765	0				Suggest avoiding the use of acronyms in the Frequently Asked Questions (FAQ) and in the Summary for Policymakers since these are aimed at general audiences. Please write out the full terms for acronyms used in the FAQs and SPM.	Government of Canada	Canada	Noted. Chapter 3 has been completely revised and most of the issues raised here are now also being addressed.
65623	0				The entire report rather freely uses the word "renewable" in contexts where one generally should use the term "low-carbon" instead. In the detailed comments, I have indicated several occurrences of such misplaced terminology. Please correct this for using "renewable" instead of "low-carbon" can have serious policy implications. The most timely example is the on-going debate regarding whether nuclear should be included in the EU taxonomy for sustainable activities or not. A thorough analysis why the term "renewable" should be substituted with "low-carbon" is available at (Harjanne and Korhonen, 2018, https doi org/10 1016/j enpol 2018 12 029).	Eero Hirvijoki	Finland	Noted. Chapter 6 does not conflate low-carbon enegy with renewable energy
65965	0				The report contains research that sets a priori limitations to nuclear energy. At the same time, the report systematically dismisses results from research that shows the importance and benefits of nuclear energy. This has to be fixed. The IPCC cannot be an organization that a priori limits any clean technology. There are numerous examples of such mispractice in the report. Below, I list some striking ones: (1) The illustrated pathway scenarios <2-Ren and 1.5-Ren explore "enhanced development and rapid diffusion of renewables", yet no illustrative pathway scenario exists that would explore similar assumptions for nuclear. COMMENT CONTINUES	Eero Hirvijoki	Finland	Noted. Chapter 6 puts no restrictions on nuclear, but simply reviews the literature.
65967	0				COMMENT CONTINUES: (2) Chapter 12 dismisses nuclear energy in discussing how renewables could power direct air capture of carbon. It cites (Breyer et al., 2019a; Breyer et al., 2019b) which concludes that "[a] common misperception is that excess electricity of a few hundreds of hours per year from solar or wind plants could be used for DAC, but detailed cost analyses show least cost of captured CO2 at 6000–8000 full load h[ours] per year, which requires a constant energy supply incompatible with the previous notion of only excess electricity utilization" and that "It should be noted that a constraint has been applied to block new fossil fuel and nuclear power installations after 2015." COMMENT CONTINUES	Eero Hirvijoki	Finland	The report reviews a broad range of scenarios and options, many of which include nuclear power
65969	0				COMMENT CONTINUES 2: (3) The discussion regarding hydrogen production in Chapter 6 ignores the possibilities offered by nuclear energy yet the cited research (Graves et al., 2011; Kayfeci et al., 2019) stresses the importance of high capacity factor and concludes nuclear to be significantly more economical in hydrogen production than the wind and solar that are strongly promoted in the current draft, e.g., in Figure 6.1. (4) Chapter 3 suggests that "[a]lso nuclear power can be part of a mitigation strategy, although its contribution does not reach more than around 20% of total TPES even in high-nuclear scenarios (see also Berger et al. (2017))." The study (Berger et al., 2017), however, describes a scenario where nuclear would provide up to 20 TWe capacity by 2100, completely pushing fossil sources out of the energy mix and being compatible with IPCC climate targets.	Eero Hirvijoki	Finland	Noted. Chapter 6 discussed multiple pathways for hydrogen production.
65971	0				COMMENT CONTINUES: An excellent illustration of the effects of not setting a-priori constraints on nuclear is provided in the US DoE report (Nelson et al., 2014, https://doi.org/10.2172/1163655) which investigates deep decarbonization scenarios for western North America and California. There, see Figure 3.4 on page 42: if new nuclear build is allowed in the surrounding states of California (California has a law that bans new nuclear), it becomes the dominant electricity source in the entire region covering 45% of total production. In addition, Figure 3.10 on page 54 shows the scenario with new nuclear allowed to be the most economical one. The authors of the paper explicitly mention that "The purpose of the New Nuclear Scenario is to compare on a level playing field the cost of decarbonization via nuclear power relative to renewable and/or CCS options." This same principle should be applied accross the reseach cited by IPCC.	Eero Hirvijoki	Finland	Noted. No response required.
65973	0				The report presents illustrated pathway scenarios that are in conflict with the projected energy use. With a confidence of 95%, the final energy use in Figure 3.7 is projected to be more than 500 EJ by 2050 and very likely more than 600 EJ. The primary energy consumption in the scenarios nevertheless is assumed to be majorily less than 600 EJ by 2050. This does not seem logical: the step from final energy use to primary energy in 2020 is almost a factor of 1.5. How would it be possible to, with a significant confidence, have access to more final energy than primary energy by 2050? Simultaneously, major developing countries such as India and many of the nations in Africa are expected to make a leap out of energy poverty similar to what happened in China during the past decades. It appears as if exploring energy efficiency would have superseded reality in the proposed scenarios, condemning developing countries to energy poverty. This issue shoulc be fixed and the chosen scenarios updated respectively.	Eero Hirvijoki	Finland	Noted. Chapter 3 has been completely revised and most of the issues raised here are now also being addressed.

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65975	0				Finally, I have to say that I strongly disagree with the given evaluations for nuclear energy with respect to the UN Social Development Goals (SDGs). The IAEA has a very clear stance with respect to the SDGs and a detailed account of the targets and measures to achieve them available at https://www.iaea.org/bulletin/57-3 . Most importantly, the United Nations Economic Commission for Europe (UNECE) has evaluated nuclear in achieving the SDGs via the United Nations Framework Classification for Resources and the United Nations Resource Management System. The report, available at https://unece.org/sustainable-energy/publications/nuclear-entry-pathways , includes explicit examples of the nuclear applications supporting every single one of the SDGs (see sections 2.2.1-2.2.17 and Figure 2.6). The authors ought to read the UNECE report and adjust the evaluation of nuclear accordingly. Also the Table 17.7 and Figure SPM.11 must be changed. Please see also my detailed comments regrding each SDG individually	Eero Hirvijoki	Finland	The report reviews a broad range of scenarios and options, many of which include nuclear power
66027	0	0	0	0	The following comments refer to the whole WG III Draft Report, specifically to questions of philosophy, ethics and political science. In particular they take Chapter 1,5,12,14-15,17, Annex A (Glossary) and the Summary for Policymakers into consideration (Furio Cerutti, Università di Firenze). 1. Following a confusion that is spreading in our days, 'ethical' is used throughout the Draft as synonymous with 'normative', obliterating the fact that there are several types of normativity, of which ethics (norms descending from moral principles) is just one, while two other types - political and legal – of normativity seem to be more directly involved in the effective shaping of climate policy (cf. 1.6.3 and passim). Think of the fundamental role of states and international organisations in the preservation of acceptable life conditions against extreme events by means of mitigation and the stabilisation of domestic and international order in front of forced mass migrations and subsequent social and interstate conflicts; but also of the funding and implementation of adaptation measures primarily for the populations most hit by climate change. A public authority that does not regard the providing of safety and security for everyone as its first mission is not credible, even less if it instead puts equity and justice alone on the top of its scale of relevance. The delicate goal of underpinning the political legitimacy (a key concept for building support, and mentioned only once at the margin in Ch. 1, nowhere in the Summary for Policymakers) of a reasonable climate policy cannot be attained just by exhibiting its presumptive high moral quality. 2.This enthronisation of ethics as only and supreme normative driver resonates with the underlying understanding of politics as an activity only driven by the (material) self interest of all actors, seen as blind and adverse to both the common good and the respect for future generations. Now, such a narrow and moralistic view of politics does not find correspondence in political philosophy, not even in political realism as a sophisticated intellectual tradition. It looks like the authors of the draft believe that the fight against global warming can be successful only if politics as the evil is replaced or redressed by ethics as the champion of justice and benevolence; in other words, if it is entrusted to 'people with altruistic and biospheric values' (Ch. 5, p.62 – not even the Oxford English Dictionary could explain to me what 'biospheric values' are). Apart from being philosophically wrong and simplistic, this view is fit to leave the political supporters of a sound climate policy toothless, as they are asked to walk out of the political game and to appeal to ethics as the supreme directive for action. An appeal whose low effectivity in real politics is well known to observers and scholars of political life. The relationship of ethics and politics is indeed much more complex than the authors of the Draft seem to assume. 3. Correspondingly the disciplines mobilised in the Draft to offer insights on climate action are economics, psychology and sociology as far as they work under the beacon of ethics, while political science appears to play a marginal role, confined as it is in special sections (as in the valuable Ch. 1.7-1.8), and in Chapter 14, which is dedicated to international relations.(By the way, I am not sure that the notion of 'multilevel governance' can be easily transferred from its place of origin, the EU studies, to climate policy, but this would deserve a lengthy discussion.) Very little however is said as to how the several political systems (e.g. authoritarian, liberal-democratic, populist; centralised or federal; free trade-oriented or protectionist) interplay with different positions in climate issues; or about the roles of public opinion, parties and movements in the same field; or on the decision-making patterns followed by relevant actors (states, blocs, COPs) in climate and energy issues – all topics widely handled in empirical research and more productive for the design of climate strategies than moral appeals. How can domestic and international coalitions supporting, say, the swift implementation of the Paris Accord be built, along what patterns? The many proposals for the economy of	Furio Cerutti	Italy	Noted. Thanks
72989	0				The report represents a crucial but missed opportunity to identify potentially feasible pathways and scenarios that were excluded by the limitations of its process and which may be capable of accelerating mitigation to outperform, for example, the C1 pathway category. The limitation arose because for the AR6 assessment only "modelling teams were invited to submit their available emissions scenarios." (Annex C, II.3.1 at C-45). Thus, non-modelling entities were generally not notified and were excluded. This excluded both qualitative and quantitative submissions that would otherwise have been made and which could have expanded the range of feasible high performance pathways. I recommend this be remedied by adding, at appropriate places in the report, qualitative evaluations of such pathways, partial pathways or approaches that are known to exist in the literature before the cutoff date. (E.g., works by Kallis on degrowth, and Edwards & Cox 2020[*]). …	Larry Edwards	United States of America	Noted. Thank you for your comment. Various sections of the report include assessment of these topics
72991	0				…(continued). [*] Published online 21-Sept-2020, https://thesolutionsjournal.com/2020/09/01/cap-and-adapt-failsafe-policy-for-the-climate-emergency/.	Larry Edwards	United States of America	Noted. Thanks
72993	0				The report omits discussion of the significant number of national & subnational declarations of "climate emergency" that have been adopted globally since December 2016. Nearly all were passed in reacting to the IPCC's 2018 SR-1.5 report and Steffen et al. 2018. The report gives only the briefest mention of climate declarations, in just a few places; it: (1) notes that Spain passed one (4-32); (2) characterizes them as a "new narrative" (5-69) and a "new framing" (5-77); and (3) as a demand of Extinction Rebellion (14-72). To date, the EU and 13 worldwide national governments have passed declarations of climate emergency (including France and three others in the EU). Sub-nationally, by current count, 1886 governments in 34 nations have passed declarations, including four significant subnational governments. (CED 2021a, CED 2021b). Among the declarations: 36% urge a zero or net-zero emission deadline of 2030 or earlier; 9% urge deadlines between 2030 and 2045; and 55% urge a "by 2050" deadline. (CED 2021a)	Larry Edwards	United States of America	Noted. Thanks

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72995	0				(Continuing)… The declarations should be discussed in the WGIII report as trending governmental and popular recognitions that range from ones that the Paris Agreement is inadequate in view of contemporarily experienced climate impacts (and that implementation of the SR 1.5's 2030/2050 recommendation will be insufficient) to ones that the Paris Agreement is acceptable but dangerously, inadequately implemented. The WGIII report should deal with this. Moreover, the European Union (comprised of 27 nations) and globally the following thirteen (13) individual nations have passed declarations of climate emergency in 2019 or thereafter: Andorra, Argentina, Austria, Bangladesh, Canada, France, Japan, Maldives, Malta, New Zealand, Rep. of Ireland, South Korea, and Spain. Declarations have partially passed in Portugal and the UK, and are in process. The following significant sub-national governments have also passed declarations: Northern Ireland, Scotland, South Australia and Wales. (CED 2021a, CED 2021b)	Larry Edwards	United States of America	Noted. Thanks
72997	0				(Continuing)… In Jan. 2021, UNDP published its poll results on the global public's climate change attitude. (UNDP 2021). Among the 1.2 million respondents from 50 nations covering 56% of the world's population: "64% of people said that climate change was an emergency - presenting a clear and convincing call for decision-makers to step up on ambition." This recognition was by universal super-majority: "The highest level of support was in SIDS (74%), followed by high-income countries (72%), middle-income countries (62%), then LDCs (58%). And it had "a high level of support everywhere - in Western Europe and North America (72%), Eastern Europe and Central Asia (65%), Arab States (64%), Latin America and Caribbean (63%), Asia and Pacific (63%), and Sub-Saharan Africa (61%)." Of individuals recognising the emergency "59% said that the world should do everything necessary and urgently in response[,] 20% said we should act slowly, while 10% percent of people thought the world is already doing enough."	Larry Edwards	United States of America	Noted. Thanks
72999	0				References for above comments: [1] CED (2021a) https://climateemergencydeclaration.org/four-years-of-climate-emergency-declarations/; [2] CED (2021b) https://climateemergencydeclaration.org/climate-emergency-declarations-cover-15-million-citizens/; [3] Becken (2021); "Decarbonising tourism: Mission Impossible?", Tourism Recr. Res. 44: 4; [4] Gills & Morgan 2020, "Global climate emergency: After COP24, climate science, urgency and the threat to humanity", Globalizations 17:6,885-902; [5] Gossling & Nilsson 2009, "Frequent Flyer Programmes as Mobility Booster?: Implications for Sustainable Aviation", in Transport & Tourism: Challenges, Issues and Conflicts. Proceedings of the Travel and Tourism Research Association Europe 2009 Annual Conference, 22-24 April 2009;	Larry Edwards	United States of America	Noted. Thanks
73001	0				More References for the above comments: [6] Stay Grounded 2020, "It's about more than just CO2: Aviation must reduce its total impact on climate", Oct 2020, https://stay-grounded.org/wp-content/uploads/2020/10/SG_Factsheet_Non-CO2_2020.pdf; [7] Steffen et al. 2018, "Trajectories of the Earth System in the Anthropocene", PNAS 115 (33) 8252-8259 ; [8] T&E 2019, "Why ICAO and Corsia cannot deliver on climate", Transp. & Env., Sep. 2019, https://www.transportenvironment.org/sites/te/files/publications/2019_09_Corsia_assessement_final.pdf; [9] UNDP (2021) "Peoples' Climate Vote: Results", https://www.undp.org/content/dam/undp/library/km-qap/UNDP-Oxford-Peoples-Climate-Vote-Results.pdf	Larry Edwards	United States of America	Noted. Thanks
73003	0				The report is biased by omitting discussion of some potential regulatory controls. In contrast to its plentiful references to taxes, levies and pricing, NOT mentioned are: carbon rationing or fuel rationing, personal carbon trading, and tradeable energy quotas (TEQs). Discussion of these and other measures is needed throughout the report, especially their ability to enable accelerated mitigation and increase the certainty of achieving mitigation targets. References: [1] Cox 2013, "Any way you slice it: The past, present and future of rationing", The New Press; [2] Fawcett 2012, "Personal carbon trading - is now the right time?", Carbon Mgmt 3(3): 283-291; [3] Chamberlin et al. 2014, "Reconciling scientific reality with realpolitik: Moving beyond carbon pricing to TEQs - An integrated, economy-wide emissions cap", Carbon Mgmt 5(4), 411-427; and Edwards & Cox 2020, Solutions Journal 11(3)	Larry Edwards	United States of America	Noted. Thanks
73011	0				In view the extreme climate-related impacts of the past few years, with their unforeseen intensity and extent, it is shocking that the least impactful pathway (C1 in Table 3.2) has a distant net-zero year of 2056 (likely, or 2045 at soonest but less likely), and would likely overshoot the 1.5oC mark by a notable 0.06 oC and perhaps nearly one-tenth of a degree. I believe additional narrative is needed in Chapters 3 & 4 and the SPM for how C1's 1.5-LD illustrative pathway might be modified for more accelerated action. That is, to make its net-zero date much sooner, to increase its likelihood of not overshooting, and to reduce its resulting peak (if any) and final temperatures. In Fig. 3.6, it appears that the fossil fuel emissions in 1.5-LD could perhaps be cut back further by steepening the cut, making it a straighter line, and trimming back the tail. …	Larry Edwards	United States of America	Noted. Chapter 3 has been completely revised and most of the issues raised here are now also being addressed.
73013	0				(Continuing)… Of course the additional cuts for doing this would have to be made by high-emissions nations (for equity), and they would have to be made by means not already included in the scenario. One way to make these additional cuts in 1.5LD may be with a fast-falling cap on the fossil fuels entering those nations' economies, and the possibility of also using of some kind of fuels- or carbon-rationing rationing. ([1] Cox 2013, "Any way you slice it: The past, present and future of rationing", The New Press; [2] Fawcett 2012, "Personal carbon trading - is now the right time?", Carbon Mgmt 3(3): 283-291; [3] Chamberlin et al. 2014, "Reconciling scientific reality with realpolitik: Moving beyond carbon pricing to TEQs - An integrated, economy-wide emissions cap", Carbon Mgmt 5(4), 411-427; and Edwards & Cox 2020, Solutions Journal 11(3).)	Larry Edwards	United States of America	Noted. Chapter 3 has been completely revised and most of the issues raised here are now also being addressed.
74667	0				Many thanks to the authors for the hard work and thoughtful analysis.	Cutting Hunter	United States of America	Noted
75081	0				Reviewing Chapters 6, 7, and the Technical Summary, I find these to be too critical of bioenergy and biofuels. Having only recently been invited to review the AR-6 report, I offer for now general comments and submit references for consideration rather than point-by-point review of the text.	Lee Lynd	United States of America	Noted. We have tried to be impartial in synthesizing the literature on all energy sources.
75083	0				General points.	Lee Lynd	United States of America	Noted
75085	0				• We cannot extrapolate an unsustainable world and get to a sustainable future. The only paths to a sustainable world involve multiple, complementary, and currently improbable combinations of changes.	Lee Lynd	United States of America	Noted
75087	0				• According to the global calculator, the impacts of societal choices on climate are at least as large for diet and land use (defined separately from diet) as for renewable energy. In the absence of a commitment to climate-responsive dietary and land choices, we will not achieve climate stabilization. In the context of such a commitment, there is plenty of room for cleverly integrated biofuels.	Lee Lynd	United States of America	Noted
75089	0				• Arguments over whether biofuels can be a huge energy supply option have impeded their development. I do not know how big the contribution of biofuels will or should be. I do know that if the current trends continue, many promising and potentially needed biofuel paths will not be available to us.	Lee Lynd	United States of America	Noted

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75091	0				• Activity in the biofuels field involving both feedstock production and conversion technology have repeatedly focused too much on deployment of solutions with mixed effectiveness relative to the SDGs, and too little focus on developing solutions for which the net benefits are clear-cut.	Lee Lynd	United States of America	Noted
75093	0				• Building on the last point, there are many who focus on tradeoffs, and complexity, and argue that our models are not good enough. While there is some truth to this perspective, not all paths to beneficial biofuels involve great complexity and some are win-win.	Lee Lynd	United States of America	Noted
75095	0				• There is increasingly compelling evidence that negative emissions will be needed in order to stabilize climate. Biomass energy is widely seen as a (many would say THE) leading negative emissions option, and biofuels have some notable and largely unappreciated advantages compared to bioelectricity in this context.	Lee Lynd	United States of America	Noted
75097	0				• While it is often assumed that he multiple linkages of biofuels (e.g. to land use, food, habitat, soil fertility, economic development) put biofuels in a negative light, the multiple linkages of bioenergy can also be used to advantage. For example, an agriculturally-based enterprise like biofuel production can be very much more beneficial than fossil fuels with respect to rural employment (see paper 9 below). As presented in paper 8, people are hungry because they are poor, the greatest numbers of hungry and poor people are in rural communities, and bringing income to these persons and value to their communities is the best way to address the linked problems of poverty and food security. There is compelling evidence that biofuels have brought social development benefits in Brazil (see papers of Moraes et al.).	Lee Lynd	United States of America	Noted
75099	0				• According to the paper of Reid et al. (GCB, 2019), which is rather critical of bioenergy, the median of 86 low carbon scenarios compiled by the IPCC for 2050 entails more biomass energy (including bioelecricity) than wind and solar combined. The biggest reason, in my opinion, is negative emissions. The Shell net zero scenario also includes as much biomass as coal, oil, and gas combined - and again features CCS.	Lee Lynd	United States of America	Noted
75101	0				• Perhaps most important, today's biofuel production/industry - which was not conceived to address climate change - are often compared to alternatives that assume willingness to make large changes to address climate change (many of which do not yet exist at scale). Not surprisingly, biofuels and bioenergy often suffer in such comparisons. When considering biofuels, we need to distinguish between two valid points: 1) Near-term GHG emission reductions can be achieved with technology we already have; 2) Biofuels could be deployed in very different ways than it is today, and likely would be if it were configured in order to maximize social benefits. I see biofuel critics often focusing only on technology deployed today (or in some cases yesterday). Meanwhile, bioenergy advocates focus too much on defending the status quo (point 1) and not enough on doing things differently in the future (point 2). With neither group focused on future possibility, I am confident that bioenergy-related technologies are evaluated more much conservatively that most other possibilities.	Lee Lynd	United States of America	Noted
75103	0				Publications I submit for consideration.	Lee Lynd	United States of America	Noted
75105	0				1. The Need for Biofuels as Part of a Low-Carbon Energy Future. Fulton, Lewis M., Lee R. Lynd, Alexander Körner, Nathanael Greene, and Luke R. Tonachel. "The Need for Biofuels as Part of a Low Carbon Energy Future." Biofuels, Bioproducts and Biorefining 9, no. 5 (2015): 476–83. With coauthors from the IEA and Natural Resources Defense Council, this paper asks: According to the IEA 2DS extended out to 2075 (for which our vision is decidedly imperfect but gives more time for penetration of new technologies), what fraction of total transport demand is difficult to electrify or provide for via hydrogen? The answer in 2015 was about half. In the five years since then, more optimism about batteries may well have emerged. However, even if revisiting this analysis would produce an answer more like a third, a) we are still a long way from realizing current optimistic forecasts, and b) emissions from this most difficult fraction of transport to render carbon neutral would still be greater than the economy-wide emissions allowable under the 2DS.	Lee Lynd	United States of America	Noted
75107	0				2. The Grand Challenge of Cellulosic Biofuels: Why Cellulosic Biofuels Have Fallen Short and What we Can Do About It. Lynd, Lee R. Nature Biotechnology 35, no. 10 (2017): 912. Title is perhaps descriptive for now.	Lee Lynd	United States of America	Noted
75109	0				3. Lynd, Lee R., Xiaoyu Liang, Mary J. Biddy, Andrew Allee, Hao Cai, Thomas Foust, Michael E. Himmel, Mark S. Laser, Michael Wang, and Charles E. Wyman. "Cellulosic Ethanol: Status and Innovation." Current Opinion in Biotechnology 45 (2017): 202–11. • General aspects of cellulosic biofuels are presented - e.g. that feedstocks are widely available at lower cost than petroleum on a $/GJ basis. • Features of the 6 pioneer plants built around the world are summarized, including their very high cost. • An example of an alternative processing paradigm with potential for much lower cost is described. Compared to the status quo cellulosic ethanol processing paradigm, the advanced scenario developed herein offers 8-fold shorter payback and economic feasibility at 10-fold smaller scale. I have recently been appointed Director of a substantial lab in Brazil aimed at realizing this potential.	Lee Lynd	United States of America	Noted
75111	0				4. Hannon, John R., Lee R. Lynd, Onofre Andrade, Pahola Thathiana Benavides, Gregg T. Beckham, Mary J. Biddy, Nathan Brown, Mateus F. Chagas, Brian H. Davison, and Thomas Foust. "Technoeconomic and Life-Cycle Analysis of Single-Step Catalytic Conversion of Wet Ethanol into Fungible Fuel Blendstocks." Proceedings of the National Academy of Sciences, 2019. This paper makes the point that biology is better at making small molecules but the fuel molecules the world most wants from biomass are large. Catalytic conversion of ethanol to hydrocarbon fuels fills this gap, appears likely to involve low costs and to pass through life-cycle benefits from ethanol.	Lee Lynd	United States of America	Noted
75113	0				5. Moreira, Marcelo MR, Joaquim EA Seabra, Lee R. Lynd, Sofia M. Arantes, Marcelo P. Cunha, and Joaquim JM Guilhoto. "Socio-Environmental and Land-Use Impacts of Double-Cropped Maize Ethanol in Brazil." Nature Sustainability, 2020, 1–8. This paper finds that corn ethanol production as it is happening now in Brazil has near zero GHG emissions and negative indirect land use change (that is, the footprint of agriculture is smaller with biofuels than without them). This is notable since maize ethanol has been extensively studied and many people think that there is nothing more to learn.	Lee Lynd	United States of America	Noted
75115	0				6. Field, John L., Tom L. Richard, Erica AH Smithwick, Hao Cai, Mark S. Laser, David S. LeBauer, Stephen P. Long, Keith Paustian, Zhangcai Qin, and John J. Sheehan. "Robust Paths to Net Greenhouse Gas Mitigation and Negative Emissions via Advanced Biofuels." Proceedings of the National Academy of Sciences 117, no. 36 (2020): 21968–77. This recent paper identifies paths to achieving large GHG benefits with biofuels that are not negated by induced land use change, carbon debt, or opportunity cost. The paper also highlights the potential of biofuels for negative emissions.	Lee Lynd	United States of America	Noted

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75117	0				7. Monteiro, Leonardo A., Andrew Allee, Eleanor E. Campbell, Lee R. Lynd, Johnny R. Soares, Deepak Jaiswal, Julianne de C. Oliveira, Murilo dos Santos Vianna, Ashley E. Morishige, and Gleyce KDA Figueiredo. "Assessment of Yield Gaps on Global Grazed-Only Permanent Pasture Using Climate Binning." Global Change Biology, 2019. Pasture land represents twice the land area of cropland but provides only about 1% of global dietary calories (and about 3% of global protein). This paper explores the potential to intensify pastureland based on what is realized today in parts of the world that have similar climate - an approach known as climate binning. The answer to this admittedly difficult question appears to be about 5-fold.	Lee Lynd	United States of America	Noted
75119	0				8. Allee, Andrew, Vikrant Vaze, and Lee R. Lynd. Cross-National Analysis of Food Security Drivers: Comparing Results based on the Food Insecurity Experience Scale and Global Food Security Index. In press, Food Security. In the most comprehensive analysis of its kind, we show conclusively that food security is best correlated with household income and has no positive correlation with the quality and quantity of agricultural land. People are hungry because they are poor, the greatest numbers of hungry and poor people are in rural communities, and bringing income to these persons and value to their communities is the best way to address the linked problems of poverty and food security. There is compelling evidence (not in this paper) that biofuels have brought social development benefits in Brazil. I hope this paper can be considered as making it under the deadline.	Lee Lynd	United States of America	Noted
75121	0				Not yet published.	Lee Lynd	United States of America	Noted
75123	0				9. Sugar Cane Bioenergy as a Development Path in Mozambique: Potential Impact and Comparison to Offshore Natural Gas. (In preparation). We are comparing the economy-side impacts of an equal investment in today's bioenergy technology and off-shore gas in Mozambique – one of the 12 poorest countries in the world with abundant unutilized land resources. The result we are working to confirm is that bioenergy brings 36-fold more jobs (direct and indirect) compared to the off-shore gas scenario.	Lee Lynd	United States of America	Noted
75125	0				10. Conception and Preliminary Analysis of Non-Competing Cellulosic Biofuel Feedstock Supply Chains (manuscript in preparation, please do not circulate). This paper starts from the departure point of imagining a biofuel feedstock supply chain that does not compete with other priorities, and in particular: • Does not require dedicated land; • Realizes negative GHG emissions; • Improves soil fertility and nutrient retention; • Is still big enough to make a meaningful contribution to climate stabilization. Working with several prominent researchers, we are developing strategies for how these criteria can be met simultaneously. In a nutshell, if crop residues are converted to biofuels with the high-lignin fermentation byproduct returned to the soil, available literature provides good – although not conclusive – indications that soil carbon and fertility can be at least as good as if the crop residues are left in the field, with substantial advantages compared to the status quo. We see significant support for the working hypothesis that with clever integration, food and feed production can be better in terms of both economics and sustainability with biofuel production than they are without biofuels. Lest this seem like science fiction, the above-described benefits are being realized simultaneously by the Italian Biogas Consortium today.	Lee Lynd	United States of America	Noted
75127	0				11. BECCS with biofuels. Looking across a variety of processes, including both first and second generation, biological and thermochemical, we are finding that although thermodynamic yields for biofuel production are rather high, that most of the feedstock carbon is available at the point of biofuel production and is thus capturable. This analysis rebuts the widespread impression that CCS is not applicable to biofuels because of the impracticality of capturing mobile emissions.	Lee Lynd	United States of America	Noted
76143	0				For improved transparency and clarity, I hope the authors can report emissions and mitigation options for individual gases wherever possible, instead of the often more ambiguous CO2-eqivalents. See more on this in Annex B section A.B.10.6: Use of GHG metrics in WGIII contribution to AR6: guidance to authors	Jan Fuglestvedt	Norway	Thank you, efforts have been made to increase the reporting of individual gases where possible based on the available literature.
76273	0				For the writing of AR6 Synthesis Report: Documentation and transparency important in underlying reports is important and will give SYR authors flexibility when integrating elements across WGs and SRs. The Annexes in WGIII are very useful also in this respect.	Jan Fuglestvedt	Norway	Thank you for the postive comment
76275	0				The covid situation is an issue that is addressed in all three Working Groups. It will strengthen the AR6 if there can be closer coordination on this across the WGs with cross referencing. Stronger coordination and closer contact between the authors on this issues can also support the Synthesis Report Authors in their work.	Jan Fuglestvedt	Norway	Noted. Thank you for your comment
76339	0				Please ensure consistency and an appropriate representation of range and uncertainty of population projections across the report. I did a cursory search across some chapters (1, 3, 4, 5, 6,and 7) but could not find a clear definition/discussion of projected population numbers and the way these were treated in the assessment. On the contrary, e.g. the numbers highlighted in Chapter 7 "e.g. ES "As the global human population approaches a projected nine billion by 2035,..", and Table 7.3 relates the latest FAO assessment as the single source, while in Ch 3 (e.g. Figure 3.7) the depicted range used in the scenario literature does not seem to reach that number even in the highest scenarios.	Gerrit Hansen	Germany	Noted. The assessment uses a variety of baselines. Authors have attempted to increase the transparency around which baseline is applicable where.
77047	0				Key Over-Arching Comments #1 to #15 are given below:	Jim O'Brien	Ireland	Noted
77049	0				#1. The WGIII report is erroneously based on over-sensitive climate models, The "most likely" unabated temperature increase, stated as 3.3°C to 5.4°C by 2100, is implausible. It bears no resemblance to the current observed trend of 0.15°C/decade, which equates to a rise of ~1.2°C by 2100. This actual global temperature trend has now been proven to be only one-half to one-third of that predicted in the CMIP5 and CMIP6 models, see for example, recent lectures by Dr John Christy at https://youtu.be/D2Cd4MLUoN0 and Dr Roy Spencer at https://youtu.be/j80PhHJbZcs. Real-world observations do not point to a climate emergency. These aspects have already been extensively pointed out in the Expert Review of the WGI SOD, which should now be reflected in WGIII.	Jim O'Brien	Ireland	Thank you. These issues are being taken care of.
77051	0				#2. As indicated in the WGIII report, the COVID-19 pandemic resulted in a mere 7% or ~3GtCO2 reduction in GHG emissions in 2020, with the associated catastrophic economic and job losses caused by the pandemic. How can WGIII plausibly recommend reductions of multiples of this reduction by 2030 and 2050 respectively without pushing the world into negative economic growth?	Jim O'Brien	Ireland	Noted. Chapter 3 has been completely revised and most of the issues raised here are now also being addressed.
77053	0				#3. On mitigation costs, the WGIII report erroneously claims that most GHG reductions can be achieved at economic costs of less than $20/tCO2. That is simply not possible; real-world real cost estimates for GHG reductions in Ireland, for example, are over $1,000/tCO2, see http://iae.ie/publications/environment-iae-report-irelands-2030-greenhouse-gas-emissions-feb-6-2017/. Back-of-envelope calculations show that the costs of abating even 1bnt of CO2 will then be >$1 trillion, which is simply unaffordable. Abating global emissions to "net zero", if technically feasible, would cost ~100% of global GDP, not the 1.6% to 4.3% suggested in the WGIII report.	Jim O'Brien	Ireland	Thank you. These issues are being taken care of.

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77055	0				#4. The WGIII report regards the Paris Agreement as mandatory, but that reflects circular/political IPCC thinking, not science. The Paris Agreement came about as a political reaction to the AR5 over-sensitive climate models. IPPC reports should focus on science, not on politics, and IPCC should now admit that basis of the Paris Agreement basis was consequently invalid. It is also noted in the WGIII report that it no longer claims that "Net-Zero" must be achieved by 2050: IPCC should now openly admit that new finding.	Jim O'Brien	Ireland	The WG III report provided extensive discussion of mitigation options that is independent of the Paris agreement.
77057	0				#5. The WGIII report refers inappropriately to the 2030 Sustainable Development Goals (SDGs); it should focus solely on science. The SDGs are in themselves highly relevant, and indeed a proper focus on these (mainly concerning the developing world) would result in much different global priorities than in the WGIII report. Only one of the 17 SDGs refers to climate change. Some 3bn people still have no electricity and some 1bn are under-nourished: these are the real emergencies and should be the real global priorities to 2030.	Jim O'Brien	Ireland	Noted. Revised
77059	0				#6. The 2020 impact of the 7% reduction in GHG emissions due to the COVID-19 pandemic made no perceptible impact of global atmospheric CO2 levels (as evidenced in the Mauna Loa data), implying zero impact on climate. This unintended global-scale experiment fundamentally questions if Mitigation has any merit; prudent Adaptation (when and where appropriate) would make a lot more sense for the planet, its economy and its 8-9bn people.	Jim O'Brien	Ireland	Reject. Thank you for your comment. The report contains an assessment of the COVID impact from mitigation perspective given the mandate of WGIII.
77061	0				#7. Energy Systems: the WGIII report erroneously extols renewables as the solution to decarbonising energy systems. While low levels of wind and solar can complement traditional generation, recent experiences in California, Texas and Australia expose the vulnerability of over-reliance on renewables. Several European networks (Germany, UK, Ireland) have had "amber alerts" this winter. Energy storage systems at grid scale will not be affordable before 2030. China, India and other countries in Asia continue to invest heavily in cheap, secure and reliable coal-fired power generation. Africa, in particular, needs cheap, reliable power to develop. Globally, renewables are not the "silver-bullet" solution.	Jim O'Brien	Ireland	Noted. Chapter 6 emphasizes the integration challenges for VRE technologies and highlights other options in addition to wind and solar power.
77063	0				#8. On Agricultural methane emissions, WGIII has inappropriately chosen the GWP100 metric just for procedural reasons. GWP100 fails to make the required distinction between situations in which the trend in methane emissions is increasing, stable or declining. In all three situations, GWP assigns a CO2-equivalent for methane based solely on the current year's emissions, thereby implying a continued methane contribution to global warming. This is unrealistic because a declining trend in methane emissions can contribute to global cooling. Using the GWP100 metric unfairly penalizes countries like Ireland and New Zealand, whose agricultural emissions are large relative to their CO2 emissions. Hence WGIII should adopt the GWP* methodology (as explained in Annex B, section A.B.10), to reflect the latest scientific data. It is even more important to incorporate the pioneering work of Happer and Wijngaarden, which proves that CH4 and N2O have insignificant GWP, see https://arxiv.org/abs/2006.03098. This topic is also under discussion in the Technical Group on Methane within the UN Food & Agriculture Organization. Unwarranted constraining of agriculture output when ~1bn people on the planet are under-nourished is simply not acceptable.	Jim O'Brien	Ireland	Rejected: as the Cross-chapter box on GHG metrics makes clear, along with supplementary material and Annex B.8, the reason for adoption of GWP100 is not only for procedural and consistency reasons, but also because GWP100 provides close to cost-effective mitigation for the temperature goal of the Paris Agreement and is consistent with a cost-benefit approach to CH4 mitigation using social discount rates. GWP* provides a useful additional perspective about the effect of cumulative methane emissions, but this does not capture the contribution to warming that each methane emission makes. Even if CH4 emissions are declining, on-going CH4 emissions do contribute to warming, not cooling; deep reductions of CH4 are needed to limit warming to likely below 2 degrees and lower (see also WGI SPM). WGIII relies on the physical science assessment of GHG metrics by WGI. The results obtained by Happen and Wijngaarden are not in the peer reviewed literature and their conclusions are not supported by the peer-reviewed literature and the WGI
77065	0				#9. Urban Systems: the WGIII report rightly points to population growth and urbanization bringing 1.3m extra people per week into cities. There is a very need to provide decent living standards and, for humanitarian reasons, this must not be carbon-constrained.	Jim O'Brien	Ireland	Accepted.
77067	0				#10. Buildings: as admitted, the WGIII report focus is developed-world-centric, devoid of understanding of the needs of the developing world. Population growth of 80m/year in the developing world demands major investment in decent homes. Some 3bn people (mostly female) suffer bad health through cooking in primitive unventilated dwellings. There is a lack of real-world priorities in IPCC thinking that runs particularly counter to the 2030 SDGs.	Jim O'Brien	Ireland	Noted. This is a very important point. Access to clean energy is addressed in Section 9.8.2.1, 9.8.2.2 and also in Section 6.3. Box 6.1 Energy access, energy systems, and sustainability covers many of these issues in detail

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77069	0				#11. Road Transport: the WGIII report misleads in stating that BEVs have lower GHG intensity have than ICEVs “if charged with low-carbon electricity”. Actual data shows that the breakeven point is 50k km even if charged with renewable power, 112k km with world average power, see for example: https://www.polestar.com/uk/electric-sustainability/transparency/. BEVs are far from being carbon-neutral, and the raw material supply chain for batteries has serious human rights questions, and there is as yet no viable battery recycling technology.	Jim O'Brien	Ireland	Noted. The analysis in chapter 10 includes the life cycle GHG emissions associated with electric vehicles, including the emissions associated with vehicle component manufacturing. Figure 10.4 in the report clearly shows that electric vehicles have much lower GHG emissions when charged with low carbon electricity than conventional ICE, even after accounting for vehicle and battery manufacturing. Regarding the second part of the comment, lithium battery minerals have been assessed in the report and the literature suggests that there are few constraints. Significant changes in the geography of mining has shifted away from places with human rights issues. Battery recycling is an agenda that needs to be given more priority. Please refer to Box 10.6 on
77071	0				#12. Industry: The WGII report should appreciate that industries have already made huge strides in energy efficiency and CO2 reduction per ton product. There is the particularly good example of the cement industry. The Global Cement and Concrete Association has now committed to a “Net-Zero Concrete” by 2050 – see https://gccassociation.org/climate-ambition/. Also, the European Cement Association has produced a similar more detailed roadmap – see https://lowcarboneconomy.cembureau.eu/carbon-neutrality/. Both ambitions have significant assumptions on technology development, availability of alternative fuels, enabling legislation, and are technically challenging and will be extremely costly.	Jim O'Brien	Ireland	Noted. Thank you for your comment. These issues are addressed in Chapter 11 of the report
77073	0				#13. In the WGII report, there is likely double-counting (or even triple-counting) between sections. For example, cement production includes estimates for indirect energy costs; buildings include estimates for embodied energy from cement and concrete. The energy balances and calculated emissions may be over-estimated.	Jim O'Brien	Ireland	Reject. Thank you for your comment. We have clear sectoral boundaries defined in Annex II of the report.
77075	0				#14. The WGIII report focuses almost entirely on (largely ineffective) Mitigation and is curiously silent on Adaptation. Increasing population and urbanization will cause increasing stress on global resources, meriting provision in global adaptation budgets. On the other hand, media hysteria on “extreme weather events”, is not demonstrated in rigorous analysis of trends. Nor is sea level rise an issue with an annual rate of increase of ~3mm/year, producing a rise of only ~25cm by 2100. Global focus should be on adaptation to real issues, and the 2030 SDGs demonstrate the real priorities, particularly for the developing world.	Jim O'Brien	Ireland	Since the focus of the WGII is on adaptation, the WGIII report focuses on mitigation. However, several chapters within the report discuss adaptation including Chapter 7 (AFOLU), Chapter 8 (Cities), Chapter 12 (cross-sectoral perspectives) and Chapter 17 (Accelerating mitigation in the context of sustainable development)
77077	0				#15. The individual sectoral chapters each have a final section on Knowledge Gaps; these should be summarized in the SPM and TS, as a matter of good governance and in the interests of objective WGIII reporting.	Jim O'Brien	Ireland	Noted
78223	0				Misrepresented fact - Almost all the chapters contain a bias against nuclear energy. Non-fossil fuels and renewable do not cover nuclear energy despite nuclear has been acknowledged as an established technology refer Figure 3.43.	Reetesh Chaurasia	India	Noted. Chapter 6 includes nuclear as a key low-carbon option.
78225	0				Misrepresented fact - Fall in tariff is a highly debatable aspect considering every source of energy is associated with a distinct distribution method. Pricing is not solely dependent on production expenses. "Likelyhood" of fall in tariff amounts to a scientifically false notion.	Reetesh Chaurasia	India	Noted. No responses required.
78227	0				Omission - Nuclear technology has several established non-power applications. Its applications include radiophamaceticals and mutation breeding technolgies have been ignored in the report. Efforts to undermine nuclear energy also disregard the otherwise massive global impacts of nuclear technolgies in healthcare and advanced agricuture.	Reetesh Chaurasia	India	Noted. No responses required.
78229	0				Misrepresented fact - Low-carbon and renewable have almost been used interchangebly in several chapters. Reference to 100% renewable option as propagated by Jacobson et al., 2017 have been duly rebutted in the past (Clack et al, 2017, https://doi.org/10.1073/pnas.1610381114) and hence should be expunged.	Reetesh Chaurasia	India	Noted. Chapter 6 does not conflate low-carbon with renewables.
79377	0	0	1000	0	The extensive use of acronyms is rather painful. Providing a list & meaning of those acronyms could be helpful.	Raymond Zaharia	France	Noted. List of acronyms will be provided for the report as a whole before publication
79397	0	0	0	0	At the bottom of page 9 of Annex A, one can read: "Climate change commitment is defined as the unavoidable future climate change resulting from inertia in the geophysical and socio-economic systems."(Continued in the next 5 cells.)	Raymond Zaharia	France	Thank you for your comment. Glossary definitions have been carefully considered to ensure terminology is consistent across the three Working Groups.

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79399	0	0	0	0	Last year, while the Glossary was offered to reviewers, the TSU Xlsx form provided for FOD review, precluded comments on Annex A. (Which BTW included differences with other IPCC reports, like for instance Annex A of SR15).	Raymond Zaharia	France	Thank you for your comment. Annex A: Glossary is provided as a reference when reviewing the reports and so is typically not open for review. We thank you for your important comments on the glossary definitions.
79401	0	0	0	0	The same unfortunate situation occurs for the present SOD Review... Precluding comments on such Glossary is debatable since its contents may be not only Policy relevant, but also Policy prescriptive. A striking example may be found in the wording quoted above. (Bottom of page 9 of Annex A of AR6-WG3 SOD. See also line 8, page 36 of SPM.)	Raymond Zaharia	France	Thank you for your comment. Annex A: Glossary is provided as a reference when reviewing the reports and so is typically not open for review. We thank you for your important comments on the glossary definitions.
79403	0	0	0	0	This wording carries implicitly the idea that inertia in the socio-economic system is, (like inertia in the geophysical system) ... unavoidable ! However there is a strong difference between: - physical laws governing the geophysical system, and - human made laws governing the socio-economic system.	Raymond Zaharia	France	Thank you for your comment. Glossary definitions have been carefully considered to ensure terminology is consistent across the three Working Groups.
79405	0	0	0	0	Indeed, it would not be Policy relevant to suggest changes to physical laws ! Conversely, it seems to me that WG3, while improving, is still missing a critical part of its duties, when it abstains to suggest "Policy relevant" changes in human made laws that are obviously detrimental for the attenuation goals in the Paris agreement !	Raymond Zaharia	France	Thank you for your comment. Glossary definitions have been carefully considered to ensure terminology is consistent across the three Working Groups.
79407	0	0	0	0	I do know that these changes suggestions could be challenged by governments, and miss the official approval during the final stages of elaboration of the AR6-WG3 report. However it seems highly desirable to avoid wording implying that human made laws, actually delaying vital attenuation efforts, cannot be changed.	Raymond Zaharia	France	Noted, thank you for your comment.
79829	0	0	0	0	The terms such as Paris targets, Paris climate targets, Paris goals, Paris Agreement goals, the Paris climate goals, climate targets, long-term goals, long-term targets, long-term objectives of the Paris Agreement, and long-term temperature goal, need to be used consistently, carefully, or separately if referring to different goals or targets. Note that the term used under the Paris Agreement is the long-term goals. It maybe helpful to add description on long-term goals under the Paris Agreement (as it includes more than the temperature goal or add a reference to Chapter 14 (for example in these terms in Chapter 3).	Madoka Yoshino	Japan	Noted. Chapter 3 has been completely revised and most of the issues raised here are now also being addressed.
80153	0	0	0	0	We propose a shift in language replacing all instances of "geoengineering" with "climate intervention." In its 2015 studies of SRM and CDR, the National Academy of Science, Engineering and Medicine adopted the term "Climate Intervention" to replace the previously used "geoengineering" to promote more accurate understanding among a wider array of audiences. As with the evolution of terminology from more technical language to "carbon dioxide removal" and "negative emissions technologies", evolution to the use of more intuitive and accessible language for SRM is likely to be beneficial to democratic engagement and societal consideration of these techniques. For these reasons, consideration of the adoption of the term "Solar Climate Intervention" in place of "Solar Radiation Management" for use in AR-6 may be warranted. (National Academies of Science, Engineering and Medicine (2015), Climate Intervention: Reflecting Sunlight to Cool Earth, NASEM, https://www.nap.edu/catalog/18988/climate-intervention-reflecting-sunlight-to-cool-earth) A nationally representative survey showed that the term "climate intervention" is more familiar, comprehensible, and neutral than "geoengineering." https://www.silverlining.ngo/us-national-survey-terminology-for-approaches-for-directly-influencing-climate Results suggest that climate intervention may be a preferable term for approaches to directly reducing Earth's warming because of better comprehension, reduced confusion, and more neutral perceptions of safety. • Familiarity with both terms is low, but 'climate intervention' is more familiar. Both terms have yet to be fully defined in the public mind, but more say they've heard of 'climate intervention' (35% have heard a lot or some) versus 'geoengineering' (19%). • Respondents were better able to comprehend what climate intervention refers to. When given a list of the same possible definitions for each term, 57% are able to correctly identify that 'climate intervention' is about efforts to combat climate change versus 22% who say this of 'geoengineering'. • By a 3-to-1 ratio, respondents felt that of the two terms, 'climate intervention' "sounds safer" than 'geoengineering'. Thirty-two percent say 'climate intervention' sounds safer, compared to 11% who say 'geoengineering' does. • By a 4-to-1 ratio, respondents were also more likely to say 'geoengineering' sounds harder to understand. Forty-five percent say 'geoengineering' sounds harder to understand, compared to 10% who say 'climate intervention' does.	Kelly Wanser	United States of America	Rejected. This term is used in the underlying literature
80423	0		0		If a page intended for A4 paper is printed on A5 and there the pages is not really legible any more, then the fonts are too small (at least according to one of my supervisors...). This is the case e.g. for tables SPM.1 and 6.9, figure TS.13 and several other figures and tables in the report.	Moritz Riede	United Kingdom (of Great Britain and Northern Ireland)	Noted, thanks

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80441	0				The bullet point E 6.3. (SPM page 37) summarises the biggest weakness I see with the WG3 second draft overall: solar PV, wind, batteries and other granular technologies have continuously exceeded model expectations in the past (see e.g. 2-75 and https://dx.doi.org/10.1038/nenergy.2017.140 for solar PV) while e.g. CCS, nuclear and bio have been slower than in the stabilisation scenarios. Yet most IAMs expect growth of renewables to fall to less than half of their recent pace and e.g. CCS, a non-granular technology, to more than double from the past rates (see e.g. 2-76 figure 2.30). This is not consistent with the past developments, but rather looks like questionable assumptions (see e.g. adoption and learning rates comparison https://doi.org/10.1126/science.aaz8060 and https://dx.doi.org/10.1016/j.joule.2020.03.010) and/or a systemic bias to me. This is as result undermining the whole IAM modelling and path development and hence the WG3 report. Most IAMs seem to favour large energy technologies and struggle to capture the upscaling of granular technologies, an issue which the WG3 draft recognises (e.g. 2-32) and in E 6.3. confirms. However, this does not seem to get really addressed, leading to inconsistencies in the report, as technological change and transition points (e.g. PV/wind + storage becoming cheaper than fossil fuel, or that the total cost of ownership of cars will very likely become cheaper for EVs than for ICEs this decade) are not well reflected in the IAMs. I wish this would be more thoroughly addressed and e.g more IAMs/pathways included where the growth of wind, solar and other granular technologies as well as their cost reduction is captured better (keeping the growth and cost reduction rates that have been shown to be possible over the last two decades for at least for the coming two decades?)	Moritz Riede	United Kingdom (of Great Britain and Northern Ireland)	Noted
80445	0		0		There are many instances, from the SPM to the individual chapters where relative changes are given in %, but an absolute reference value is not provided, which however, would be needed to make sense of these statements. For example, in chapter 6.4.2.1 (6-24) is says “Cost have declined by 62% since 2015 and are anticipated by an additional 16% by 2030.” No absolute value is given nearby (suggestion to improve this example given in another comment)	Moritz Riede	United Kingdom (of Great Britain and Northern Ireland)	Noted. Chapter 6 has included more absolute values.
80955	0				The report is presenting a wealth of information and analysis about all aspects to mitigae climate change. However, it misses one of the most important developments of the past year(s), which is the role that hydrogen is going to play as a carbon free energy carrier alongside electricity. Hydrogen can be transported worldwide by ship and pipeline and can be stored underground in large volumes. This makes it possible to deliver cheap renewable energy, especially solar and wind, cost-efficiently at the right time and place to customers. How Hydrogen empowers the energy transition, Hydrogen Council, 2017, Hydrogen key to a carbon free energy system, Ad van Wijk, in Hydrogen Technologies for sustainable economy, de Gruyter 2021	Ad van Wijk	Netherlands	Noted. Hydrogen receives extensive treatment in Chapter 6.
80957	0				The role of hydrogen is recognized all around the world, today over 30 countries have already implemented hydrogen strategies.The vast majority of these hydrogen strategies have been implemented in 2020. Among others, Japan, South Korea, Australia, Chili, Morocco, China, Russia, Saudi Arabia, Austria, France, Germany, the Netherlands, Norway, Portugal and Spain. In Europe on 8 July 2020 the European Commission released the Hydrogen Strategy for a Climate-neutral Europe as part of their European Green Deal. The strategy defines a target of 1 million ton of hydrogen and an electrolyser capacity of 6GW by 2024, and 10 million ton and at least 40GW electrolyser capacity by 2030. Besides it recognises the importance of hydrogen import from neighbouring regions, especially North Africa. A hydrogen strategy for a climate neutral Europe, EU commission, july 2020	Ad van Wijk	Netherlands	Noted. Hydrogen receives extensive treatment in Chapter 6.
80959	0				The main goals of current Hydrogen strategies are; reduction of greenhouse gas emissions, especially in hard to abate sectors, diversification of energy supply, integration of renewables, foster economic growth, support national technology developments, security of supply and strategic reserves and last but not least developing hydrogen for export and import. Hydrogen Study: International H2 Strategies. Ludwig Bölkow systemtechnik, september 2020.	Ad van Wijk	Netherlands	Noted. Hydrogen receives extensive treatment in Chapter 6.
80961	0				It is evident that there is a geographic mismatch between the good solar and wind resources sites and the energy demand areas. Worldwide good solar resources areas can be found in desert areas especially around the tropics. Good wind resources are present at the oceans and seas, but also at specific onshore locations such as the Sahara desert, Patagonia and at coastal areas. Although many regions in the world can produce renewable and/or low carbon hydrogen at low cost, it is obvious that certain regions will become net exporters and other regions will become net importers of renewable energy by hydrogen or hydrogen derivatives like ammonia. And even within regions, there will be hydrogen trade, import and export. Therefore hydrogen and derivatives will become the energy commodity that can be internationally transported and traded. Hydrogen Insights, A perspective on hydrogen investment, market development and cost competitiveness, McKinsey, februari 2021	Ad van Wijk	Netherlands	Noted. These topics are covered extensively in Chapter 6.
80963	0				Japan/South Korea/parts of China, Parts of US, and the European Union as examples, will become net importer of low-cost hydrogen, not only because of their modest renewable energy resources, but also due to their restricted area size and high population density. As an example the Sahara Desert is the sunniest year-round area in the world and has also very good wind resources sites. It is a large area at 9.4 million square km, more than twice the size of the European Union. While the population density in the EU is 117 persons per square km against less than 1 person per square km in the Sahara desert. Countries suc as Australia, New Zealand, Morocco, Chili, Norway, Saudi Arabia, Portugal and Spain have already developed or are developing hydrogen export strategies	Ad van Wijk	Netherlands	Noted. These topics are covered in Chapter 6.
80965	0				At good renewable resources sites (10-20 USD/MWh electricity cost) low cost green hydrogen can be produced that can compete around 2030 with present day fossil grey hydrogen cost (1-1,5 USD/kg) and in the long run with electricity cost below 10 USD/MWh even with natural gas. Of course electrolyser CAPEX and OPEX cost reductions are important, but electricity cost is the dominant cost factor. With a conversion efficiency of 50 kWh/kg H2, every cent per kWh electricity cost (=every 10 USD/MWh) adds 0.5 USD/kg cost to the total hydrogen cost. A perspective on hydrogen investment, market development and cost competitiveness, McKinsey, februari 2021, Hydrogen Economy Outlook, BloombergNEF, march 2020	Ad van Wijk	Netherlands	Noted. These topics are covered in Chapter 6.

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80967	0				Alkaline electrolyser technology is a hunderd year old technology, today in use for chlorine production from dissolved salt (NaCl) in water, with by-product hydrogen. The world wide installed capacity of alkaline electrolysers is roughly 20 GW. These alkaline electrolysers can be easily adapted for hydrogen production, while also new electrolyser technologies, such as PEMEL and SOEC are in development. It is an electrochemical conversion technology, with a similar technology structure as Solar PV or batteries. Electrolysers are build up from electrolyser cells, cells are stacked onto each other to a stack (called a module for Solar PV), with capacities of 0.1-5 MW). For GW electrolysers numerous stacks are installed, reducing the balance of plant cost per kW installed. The Future of Hydrogen, IEA, 2019. Of course technology improvements by R&D are important to bring down costs, but especially mass production of cells and stacks, system integration with solar and wind and multi-GW renewable hydrogen production plants, will bring down the CAPEX and OPEX cost. These multi-GW renewable hydrogen production plants are connected to the solar PV and/or wind turbines and not to an electricity grid. Green Hydrogen for a European Green Deal; A 2x40GW Initiative, Ad van Wijk, Jorge Chatzimarkakis, March 2020	Ad van Wijk	Netherlands	Noted. These topics are covered in Chapter 6.
80969	0				Many studies have made hydrogen production cost analysis, amongst which The IEA, Bloomberg-NEF, DNV-GL, the Hydrogen Council and many others. In general for all mature hydrogen production technologies, the energy cost are the most important factor in the hydrogen production cost. The IEA analysed the production cost of hydrogen from natural gas in several parts of the world. The hydrogen production cost are the lowest in regions with low gas prices, the Middle East, the Russian Federation and North America and highest in gas importing countries such as Japan, Korea, China and India. Gas prices vary between 3-11 dollar per Million Btu (0,010-0,038 dollar per kWh) with fuel costs the largest cost component accounting for between 45% and 75%. The hydrogen production cost by SMR from natural gas vary between 0,9 to 1,8 dollar per kg H2 The hydrogen production cost by SMR with carbon capture and storage (CCS) are also calculated by the IEA. The results show that CCS adds about 0.5-1 dollar/ kg H2 to the hydrogen production cost. If a carbon tax is added to the hydrogen production cost from natural gas by SMR, every 10 dollar per ton CO2 price adds about 0.1 dollar/ kg to the hydrogen price. The Future of Hydrogen, IEA, 2019	Ad van Wijk	Netherlands	Noted. These topics are covered in Chapter 6.
80971	0				If a comparison is made between hydrogen production from natural gas and hydrogen production from solar PV electricity, a similar cost structure is seen. Natural gas cost of 3 million BTU (0,01 dollar per kWh) contributes about 0,5 dollar/kg H2 which is the same for electricity cost of 0,01 dollar per kWh. SMR CAPEX cost, estimated by IEA, are between 500 and 900 dollar per kW and with 8.000 full load hours it contributes about 0,5 dollar/kg H2 to the hydrogen cost. This equals the CAPEX cost of 250 dollar/kW for electrolysers with 2.000 full load hours, which is the case for solar PV	Ad van Wijk	Netherlands	Noted. These topics are covered in Chapter 6.
80973	0				Large scale renewable hydrogen production will take place at the renewable production site and not at the demand site where the electrolysers needs to be connected to the electricity grid. The main reason is that hydrogen transport by pipeline is more cost-effective (up to a factor of 10) than electricity transport by cable. Pipeline transport capacities (10-20 GW) have larger capacities than electricity cable capacities (1-4 GW). Whereby pipeline transport distances are up to 5,000 km. So instead of transporting bulk electricity over long distances, a more cost-efficient way would be to transport hydrogen. In addition, hydrogen, like natural gas, can be stored over seasons and can hence serve as a dispatchable source of bulk energy, a distinctive advantage over electricity. A transnational hydrogen gas pipeline system is therefore a prerequisite to transport hydrogen from the resource locations to the demand sites. Large scale hydrogen storage facilities in salt caverns or possibly empty gas fields, needs to be integrated in such a hydrogen transport system to be able to deliver hydrogen at the time of demand. Such a hydrogen gas infrastructure looks very much the same as present day natural gas infrastructure, whereby natural gas is transported from (often remote) gas fields to the demand. Hydrogen key to a carbon free energy system, Ad van Wijk, in Hydrogen Technologies for sustainable economy, de Gruyter 2021	Ad van Wijk	Netherlands	Noted. These topics are covered in Chapter 6.
80975	0				Hydrogen transport by pipeline is already common practice for decades. As an example, Air Liquide operates an hydrogen pipeline infrastructure for many decades from the Netherlands, throughout Belgium to the North of France. But also the existing natural gas pipeline infrastructure could be re-used for hydrogen transport, both the large transport steel pipelines as the distribution PE or PVC pipelines could be relatively easy and cheap re-used for hydrogen transport, as shown by several studies from gas TSO's, KIWA, DNV-GL and others. A group of 11 European gas infrastructure companies have presented in July 2020 their roadmap to realize a dedicated European Hydrogen Backbone. A hydrogen backbone, based on converted 36 and 48 inch gas pipelines, can transport around 8 respectively 15 GW hydrogen (HHV) per pipeline. Their estimate is that a European Hydrogen Backbone consists of 75% converted gas pipelines and 25% new hydrogen pipelines, with 5,000 full load operating hours per year, transportation cost will be about 0.13 Euro/kgH2/1000km. However, building new large dedicated pipelines, transporting base-load hydrogen with up to 100 bar pressure, could reduce transport costs even below 0.1 Euro/kgH2/1000km. European Hydrogen Backbone, 11 gas TSO's and Guidehouse, July 2020	Ad van Wijk	Netherlands	Noted. These topics are covered in Chapter 6.
80977	0				Salt caverns can be used to store hydrogen in the same way as that they can store natural gas. World wide a couple of salt caverns are already in use for hydrogen storage. In the UK, a salt cavern has been in use for hydrogen storage since 1972. Also in the US, salt caverns have been used to store hydrogen for many years. In a typical salt cavern, hydrogen can be stored at a pressure up to 200 bar. The storage capacity of a salt cavern is up to 6,000 ton hydrogen (236,6 GWh HHV). Hydrogen generation by electrolysis and storage in salt caverns, Michalski et al. Int. Journal of Hydrogen, 2017 The total installation costs, including piping, compressors and gas treatment, are about € 100 million, which is less then 0.5 Euro/kWh CAPEX cost for hydrogen storage. Technical potential of salt caverns for hydrogen storage in Europe, Caglayan et al., Int. Journal of Hydrogen, 2020	Ad van Wijk	Netherlands	Noted. These topics are covered in Chapter 6.
80979	0				Especially Europe has still many empty salt caverns available for large scale hydrogen storage. Among others, Gasunie, the Dutch gas TSO, is preparing a couple of salt caverns for hydrogen storage, the first will be operational in 2026. World wide dedicated salt caverns for hydrogen storage capacity can be developed in salt formations. In Europe there is a huge potential for hydrogen storage in salt caverns all over Europe, Total onshore salt cavern storage capacity is 23,200 TWh of which 7,300 TWh could be developed taking into account a maximum distance to the shore of 50 km, called the constrained storage capacity. This maximum limit is set for the brine disposal. The offshore storage capacity is even larger than the onshore capacity, 61,800 TWh. Technical potential of salt caverns for hydrogen storage in Europe, Caglayan et al., Int. Journal of Hydrogen, 2020	Ad van Wijk	Netherlands	Noted. These topics are covered in Chapter 6.

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80981	0				Hydrogen transport by ship makes it possible to transport hydrogen world wide. Hydrogen can be transported by ship as liquid hydrogen, by converting it to ammonia (NH3) or by binding the hydrogen to a liquid organic hydrogen carrier (LOHC). All three have different characteristics and advantages. Liquid hydrogen transport has the advantage that it can be transported by ship at sea and truck on land to fueling stations. Liquid hydrogen transport by truck can carry 4-10 times as much hydrogen as compressed hydrogen transport by truck and is therefore cheaper. However, liquid hydrogen transport by ship is new and these carriers have to be development and build. Ammonia transport by ship is a mature technology with supply chain and in use by the fertilizer and chemical industry. Ammonia can be used in diesel engines, transported inland by pipelines (ammonia pipeline infrastructure existing in the US) by ship, rail or truck and/or cracked back to hydrogen. LOHC can be transported by existing oil tankers and stored in oil tanks and can therefore re-use existing oil assets. The LOHC's can be transported inland by pipeline, ship, rail or truck. Dehydrogenation can be done in port areas or at the use sites, whereby the carrier has to be transported back. Several ports are developing hydrogen import and export facilities and strategies. As an example the port of Rotterdam has developed a hydrogen strategy, in which they forsee to import 20 million tonnes (788 TWh (HHV)) hydrogen in 2050 Hydrogen economy in Rotterdam starts with backbone, Port of Rotterdam, 2020	Ad van Wijk	Netherlands	Noted. These topics are covered in Chapter 6.
80983	0				Hydrogen is a liquid at -253 degrees Celsius. Hydrogen liquifaction is a mature technology, in use for many decades. Liquid hydrogen transport by truck is in use for many decades too. Liquid hydrogen is used as a rocket fuel or to create very clean environments to produce chips. However, at present hydrogen liquefaction plants are small scale plants. For use as an energy carrier the capacities needs to be scalled up considerable. Existing small scale liquefaction plants use about 10-12 kWh/kg H2 (1 kg H2 = 39.4 kWh (HHV) of 33.3 kWh (LHV)) to liquefy hydrogen. At present new built 50 tonnes per day hydrogen liquefaction plants uses between 6-8 kWh/kg H2. This represents an efficiency loss between 15-20% on HHV. (The thermodynamic ideal work for gaseous hydrogen to liquid hydrogen is 3.3 kWh/kg H2). So the energy cost added to liquefy 1 kg hydrogen, with 20 USD/MWh, are adding between 0.12-0.16 USD/kg H2. Transport of liquid hydrogen by ship is new, Kawasaki has launched a first small scale liquid hydrogen carrier in december 2019. They ship liquid hydrogen produced from brown coal with CCS in Australia to Japan The liquid hydrogen delivered at the terminal in Kobe is estimated to cost 330 Yen(2015)/kg H2 of which 175 Yen is for lliquefaction, loading and shipping. Study on Introduction of CO2 Free Energy to Japan with Liquid Hydrogen, Kamiya et al. Physics Procedia, 2015. More recently several supply chain studies have been carried out. As an example the cost for liquid solar PV hydrogen from Oman delivered at the terminal in Rotterdam Netherlands in 2030 is below 2 Euro/kg H2. It is assumed that the liquid hydrogen carrier uses the boil-off hydrogen in an on-board fuel cell for propulsion. Shipping Sunshine, Roobeek TUDelft, 2020	Ad van Wijk	Netherlands	Noted. These topics are covered in Chapter 6.
80985	0				Gas or coal can be converted to hydrogen, whereby the CO2 is captured and stored underground. Converting gas or coal to hydrogen results in a pure CO2 gas flow, which is easier to capture then the CO2 that has to be separated from flue gasses that results from burning gas or coal. These pre-combustion CCS technologies are generally more cost effective than post-combustion CCS technologies. Low-carbon hydrogen can be produced at the good renewable resource sites or at gas or coal resource sites with direct CCS, transported by ship or pipeline and stored in salt caverns to match supply and demand. Gas producing countries/companies from Norway, Saudi Arabia, are implementing low carbon hydrogen export strategies based on both hydrogen production from their gas and renewable resources. The result is an energy system, whereby international transport of fossil fuels is replaced by international transport of low carbon/green hydrogen and hydrogen derivatives.	Ad van Wijk	Netherlands	Noted. These topics are covered in Chapter 6.
80987	0				A scaled-up industry could deliver hydrogen for a benchmark cost of $2/kg in 2030 and $1/kg in 2050 in many parts of the world Hydrogen is likely to be most competitive in large-scale local supply chains. Clusters of industrial customers could be supplied by dedicated pipeline networks containing a portfolio of wind- and solar-powered electrolyzers, and a large-scale geological storage facility to smooth and buffer supply. Our analysis suggests that a delivered cost of green hydrogen of around $2/kg ($15/MMBtu) in 2030 and $1/kg ($7.4/MMBtu) in 2050 in China, India and Western Europe is achievable. Costs could be 20-25% lower in countries with the best renewable and hydrogen storage resources, such as the U.S., Brazil, Australia, Scandinavia and the Middle East. However, cost would be up to 50-70% higher in places like Japan and Korea that have weaker renewable resources and unfavorable geology for storage. Citation from Hydrogen Economy Outlook, key messages, BloombergNEF, 2020	Ad van Wijk	Netherlands	Noted. These topics are covered in Chapter 6.
80989	0				A scaled-up hydrogen industry could deliver hydrogen by pipeline or ship for about 1-2 USD/kg H2 at many parts in the world. This 1-2 USD/kg H2 price is equal to 25-51 USD/MWh H2 (HHV). Of course, the hydrogen can be used to de-carbonise hard to abate sectors. But the imported hydrogen will also compete with local produced renewable energy, especially with renewable electricity from solar and wind. Energy use will become a trade off and competition between local/regional produced electricity, regional produced hydrogen and imported hydrogen in all sectors. So for high temperature heating in industry, for mobility, for heating and cooling buildings and houses and even for electricity production/balancing. Besides, in many regions around the world it is not possible to produce sufficient volumes of renewable electricity, due to all kind of constraints such as available area size, population density and opposition or other area restrictions (nature reserves, air fields, etc.)	Ad van Wijk	Netherlands	Noted. These topics are covered in Chapter 6.
80991	0				In a transitional period, hydrogen can be used by combustion in a boiler, furnace, engine or turbine, to produce heat, electricity or mechanical power. However, in future electrochemical conversion via fuel cells will become more important. The fuel cell reaction is the reverse of the electrolyser reaction.Fuel cells systems have been developed over the past years especially by car manufactures for drive trains in all kind of mobility. Fuel cells have a similar technology structure as electrolysers, batteries or solar PV, it is cells, stacked together in a stack, whereby stacks are build together with other equipment to a fuel cell system. R&D is of course important to bring down cost, increase efficiencies, reduce degeneration and bring down the amount of materials, especially Platinum (Platinum content of present day fuel cells in a car, is brought down to less then 12 grams. This 12 grams is the amount of platinum which is in the catalyst of cars today already). But especially fuel cell and stack mass production will drive down cost drastically. Mass production of cells and stacks (Plants that produces 500.000 fuel cell systems per year) will bring down fuel cell system Capex cost for cars to $ 30-40/kW. Direct Hydrogen fuel cell electric vehicle cost analysis, Thompson et all, Journal of Power Sources, 2018. Fuel cell capex cost will be lower and conversion efficiencies are higher than for present day combustion technologies, such as engines or turbines. Therefore fuel cell technology will be at least cost competitive, but in most cases cheaper then present day combustion technology	Ad van Wijk	Netherlands	Noted. These topics are covered in Chapter 6.

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80993	0				Fuel cell systems are developed by car manufacturers as drive trains in Fuel cell electric vehicles. However, these fuel cell systems can be applied in other transport such as ships, trains, drones and planes. But besides these applications in mobility, fuel cell systems will play a crucial role in other applications too. Fuel cells that produce electricity and heat will be used in houses and buildings. The volume and temperature level of the heat can be brought to the desired level by using heat pumps. Next to producing heat, the produced electricity from the fuel cells supplements the electricity from solar panels on the roof. Panasonic in Japan has introduced a small scale (< 1 kWe) fuel cell home system, that can be connected to the natural gas grid, the natural gas is reformed to hydrogen by a small reformer on top of the fuel cell. Already a couple of 100.000 of these systems are sold in Japan. Fuel cells systems can be used as electricity balancing plants, producing electricity at moments that renewable sources can not meet the demand. These fuel cell systems can be installed very de-centralized in villages, neighbourhoods and at office sites. De-centralized fuel cell systems can produce electricity and heat locally.	Ad van Wijk	Netherlands	Noted. These topics are covered in Chapter 6.
80995	0				In this report, the dominant thinking is that mainly solar and wind electricity will become cheap, that most of the end-use can be electrified and that an electricity infrastructure with all kinds of flexibility and storage technologies can balance supply and demand. Only for hard to abate sectors, hydrogen, next to several other options, is sometimes seen as an decarbonisation option. And implicitly and sometimes explicitly hydrogen production by electrolysis is assumed to be electricity grid connected, using excess renewable electricity. I fully agree with the fact that solar and wind electricity will become cheap, that electrification of end use will increase considerably and for that electricity infrastructure with integrated flexibility and storage options needs to be expanded. However, these analysis misses elements such as spatial distribution of good wind and solar sites around the world, large scale energy transport and storage needs and energy system cost analysis including production, transport and storage cost. By converting large scale multi GW solar and wind electricity at the resource sites in hydrogen, transport and storage of cheap renewable electricity all around the world becomes possible at reasonable cost. Hydrogen makes it therefore possible to exploit and integrate even larger amounts of cheap renewable electricity. Around the world for many applications and sectors, there will emerge a price competition between renewable electricity and hydrogen, how to decarbonise energy use in a cost effective way. Often smart combinations of technologies and energy carriers will provide decarbonised energy services at the lowest cost. Electricity and Hydrogen will therefore become the zero-carbon energy carriers that offer the promises for a fully decarbonised energy system.	Ad van Wijk	Netherlands	Noted. These topics are covered in Chapter 6.
81581	0	0	0	0	These comments represent the range of views of officials in the New Zealand Government	Government of New Zealand	New Zealand	Noted. Thanks
84593	0				Thank you WG III authors for your hard work on the SOD!	Kaisa Kosonen	Finland	Thank you for the postive comment
84595	0				There are inconsistencies in how 1.5°C and 2°C are referred to. Sometimes they are lumped together, sometimes findings for 2°C are presented first (and bolded) and only then the results for 1.5°C (not bolded), while in some occasions the results are presented only for 2°C without considerations on what pursuing 1.5°C would mean in the same context (or an explanation on why findings for 1.5°C can't be assessed). Please make the report consistent and easy to understand for policymakers and others who have, since the Paris Agreement and SR15, shifted their focus from 2°C to 1.5°C.	Kaisa Kosonen	Finland	Noted. Thank you for your comment. This has now been clarified in the report and the SPM.
84833	0	0			It should be considered the adaptation mechanism for climate change beside the mitigation action. When you apply nature-based solutions in urban design and implementation is broadly recognized the benefits and co-benefits provided for adaptation to climate change.Therefore, I would recommend to introduce the adaptation benefits and co-benefits of nature-based solutions interventions in cities.	Maria Carmen Garcia Mateo	Spain	Accepted. There is a cross-working group box on integrating urban mitigation and adaptation. Furthermore, the section on nature-based solutions and urban green and blue infrastructure explicitly discusses their co-benefits.
85695	0	0	0	0	Suggest correcting the definition of Energy Efficiency in Annex A, which is not consistent with the International Energy Agency's (IEA) approach to energy efficiency. https://www.iea.org/articles/energy-efficiency-and-digitalisation defines energy efficiency as: 'A reduction in energy used per unit of activity'. The IEA's 2014 Capturing the Multiple Benefits of Energy Efficiency report defines energy efficiency as: 'the ratio of energy consumed to the output produced or service performed' (p. 29), and energy efficiency measures as: 'any action or activity undertaken with the aim of improving the ratio of energy consumed to the output produced or service performed.' (p. 214). The definition is also unclear and appears to confuse energy intensity with energy efficiency. Suggest using the following definition: 'Energy efficiency - The ratio of energy consumed to output or useful energy or energy services or other useful physical outputs obtained from a system (for example, kWh/tonne). There are a number of different metrics that can be used to measure energy efficiency. Examples include input energy over a physical or economic unit, such as kWh/USD or kWh/tonne. For buildings, it is often measured as kWh/m2, and for transport km/litre or litre/km. Energy efficiency policies often refer to measures that reduce energy demand such as technological options (insulating buildings, more efficient appliances, efficient lighting, efficient vehicles), behaviour changes, or more efficient designs etc.'	Government of Australia	Australia	Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definition of Energy Efficiency is consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.
6031	1				I think considering climate change AND poverty together is integral. The choice between putting food on the table and reducing one's carbon footprint is an easy decision to make, though not good for emissions mitigation. I would like to see consideration of Gen IV reactor technologies. In addition to potential nuclear waste reduction high temperatures can reduce generation inefficiencies, and the flexibility to provide process heat directly is possible. This eliminates conversion losses from heat to electricity and back to heat for industrial processes, and also allows decarbonistion of a "hard to decarbonise" sector (industrial heating).	Adam Burak	United States of America	The report reviews a broad range of scenarios and options, many of which include nuclear power

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12185	1	1	99	70	Congratulations to the whole team for progressing the Report so far during these difficult, testing COIVID-19 times. In addition to the specific comments in this review, three generic comments that the team might reflect on follow. Firstly, the treatment of CDR across the report pays only limited attention to the critically important governance issues related to the development, uptake and delivery of CDR into the future. Whilst Chapter 12 explores the issue, that analysis lacks depth. Specifically, more attention to monitoring, reporting and verification (MRV) (including the need for a global accounting system), trade-off issues, the interrelationships between CDR and the SDGs, mitigation deterrence (or 'moral hazard'), risk-risk trade-offs, incentives, research governance and the critically important governance of sequestration and permanency would be welcome. Secondly, situating the discussion of Solar Radiation Modification (SRM) within Chapter 14 (Section 14.4.5 and the Cross-Working Group Box), with very little cross referencing to it elsewhere, leaves the important topic somewhat 'hidden'. It would be useful if the Executive Summary of Chapter 14 (pages 3-4) were to include reference to the section and Box, highlighting some key points. Finally, the discussion of SRM (14.4.5) focusses on evidence from Stratospheric Aerosol Injection (SAI) simulations that have used the most widely available types of studies - idealized or high-emission deployment scenarios with large radiative forcing. Given that the most likely future scenario for SAI is a limited scale deployment to achieve temperature targets in conjunction with mitigation (i.e., emissions reductions, CDR plus SAI to avoid overshoot), the dearth of studies that examine this scenario is important and could usefully be noted. It would also be welcome if the report could clearly note that further modelling and other research on such 'overshoot' scenarios could provide better, more context appropriate understandings of potential SAI risks and benefits. For an overview of the governance issues mentioned above, and why SRM might most likely be used in overshoot scenarios, the following may be useful: Mace et al., 2021. Governing large-scale carbon dioxide removal: are we ready? An update. Carnegie Climate Governance Initiative (C2G), February 2021, New York, US. https://www.c2g2.net/wp-content/uploads/are-we-ready_2021_fullreport.pdf Honegger et al., 2018. Carbon Removal and Solar Geoengineering: Potential implications for delivery of the Sustainable Development Goals. Carnegie Climate Governance Initiative, May 2018, New York, U.S. https://www.c2g2.net/wp-content/uploads/C2G2-Geoeng-SDGs_20180521.pdf Carnegie Climate Governance Initiative Evidence Brief: Carbon Dioxide Removal and its Governance https://www.c2g2.net/wp-content/uploads/CDR-Evidence-Brief.pdf Carnegie Climate Governance Initiative Evidence Brief: Governing Solar Radiation Modification https://www.c2g2.net/wp-content/uploads/c2g_evidencebrief_SRM.pdf	Paul Rouse	United Kingdom (of Great Britain and Northern Ireland)	Noted, thanks
14677	1	1	1	1	This comment relates to the Glossary, Annex A. At present, entries on methane and nitrous oxide refer to the "six" greenhouse gases controlled by the Kyoto Protocol. However, the Doha Amendment, which entered into force on 31 December 2020, introduced a seventh GHG, namely, NF3, to apply to the second commitment period (2013-2020). So this should read "seven" GHGs. Alternatively, a footnote should be included to note that NF3 was added from 2013, or to make things easier, it would be fine not to give any number at all.	Joanna Depledge	United Kingdom (of Great Britain and Northern Ireland)	Thank you for your comment. This definition is not longer in use.
16979	1		1		This concerns Annexe A (which is not an offered choice in the chapter section of this document) : NCPs: Nature Contributions to People could be added to this glossary.	Government of France	France	Nature's contributions to people is defined in the glossary
17767	1				general comment on FAQs: Some are very useful, but many (not all) are written in difficult technical or bureaucratic language. This will still work for those with a strong incentive to learn about the subject, but may be offputting for media and other non-specialists. Would be good to review the language and approach to see where it can be made more accessible.	Jonathan Lynn	Switzerland	Noted. Chapter 3 has been completely revised and most of the issues raised here are now also being addressed.
19055	1	1	5000	70	We would like to thank the authors for producing an excellent draft under such difficult circumstances. Whilst we have provided many constructive comments, we believe the Second Order Draft is in a good condition and is a great stepping stone towards the final report. In particular, the SPM is concise and largely well written and constructed. The positive tone of the report is welcomed and will, no doubt, be appreciated by the decision-makers who will eventually use the report to evidence their work.	Government of United Kingdom (of Great Britain and Northern	United Kingdom (of Great Britain and Northern Ireland)	Thank you for the postive comment
19057	1	1	5000	70	Policymakers will be particularly interested in information regarding peak emissions years and timing of global net zero for both CO2 and GHGs. However, in the current draft, the information presented in the SPM does not accurately reflect the analysis or give a clear picture of these key characteristics of pathways for 1.5 and 2C. The text over-simplifies some of the key results of the report, particularly those from Table SPM.1 and could lead to misinterpretation of the scale of action required. For example, the sentence in Section A of the SPM regarding the timing of peak emission dates and net zero dates does not adequately communicate the details of the analyses that produced those results. Whilst we appreciate the effort that has gone into summarising a lot of work into one sentence it is not, in our opinion, providing the right information for policy makers to correctly interpret and use these results. This sentence should be revised – we have provided specific comments in the relevant places – and all instances where complex results have been simplified should be checked for the extent that they reflect the actual results, including their nuances, limitations and ultimate utility for policy makers.	Government of United Kingdom (of Great Britain and Northern Ireland)	United Kingdom (of Great Britain and Northern Ireland)	Noted. Thank you for your comment. We have revised the text and added a more detailed analysis.
19059	1	1	5000	70	Given that the most likely publication date for WGIII will be 2022, there is an issue throughout the report regarding the appearance of using out of date data i.e. the most recent emissions data used in the report will be from 2018 and none of the policies described as "current policies" will include anything from COP26 or, most likely, after 2020. As a result, we request that: 1) authors ensure that it is very clear which data are being used in any analysis or discussion. In particular, we propose that "current policies" is not used at all and that it is replaced with "2018 policies" or similar so that there is no confusion regarding the basis of WGIII analyses. 2) authors clarify the nature of data where it could be confusing to readers. For example, Table SPM.1 should make it very clear that the emissions from 2020 are modelled and not observed. 3) authors should make every effort to update data, analyses and discussions where possible. Whilst we accept that there is a cut-off date for literature that can be cited in the report, it is also possible for authors to conduct their own analyses to feed into the report. This could, for example, have a large positive impact by attempting to incorporating NDC pledges up to COP26. For example, Figure SPM.6 specifies that it does not include updates submitted since November 2020, however there have been notable updates since this – the UNFCCC has recently produced an NDC synthesis report, which could examined in line with the guidelines on grey literature - and there will likely be more before the end of 2021, potentially significantly affecting these scenarios. We would urge the authors to constantly revisit this and other findings related to NDCs, such that it is as up-to-date and policy-relevant as possible at the point of publication.	Government of United Kingdom (of Great Britain and Northern Ireland)	United Kingdom (of Great Britain and Northern Ireland)	Noted. Thank you for your comment. We have clarified the labels of the policies to reflect their dates, and clarified the nature of the data used. This is done in both the SPM and the relevant parts of the report

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19061	1	1	5000	70	Whilst an analysis of feasibility is welcome, we are concerned that the methods for presenting these results in the SPM (particularly Fig SPM.10 but not limited to that figure) have over-interpreted and over-formalised what is a useful but relatively subjective analysis of the literature. Specifically, we are concerned that: 1) Experts, or others, looking at the matrix are very likely to question the robustness when it makes absolute statements that appear unjustifiable e.g. is there really “no evidence” on the economic feasibility of transformations in industry? Intuitively, this appears to be obviously wrong even if the details of the method mean that under the conditions of analysis this is right. 2) It seems unclear as to what a policy maker, or others, would do with some of the other conclusions from the matrix e.g. what can one learn from a “high confidence” assessment that there is “mixed evidence” at a specific point on the matrix? 3) There are no uncertainty bounds/confidence levels attributed to the pathways analysis. If they were added, would there be any significant difference between the two scenarios? It could be argued that even recent developments (e.g. price reduction in offshore wind) seemed quite uncertain until they were imminent so what can we say robustly about the feasibility of developments in the late 21st Century? We suggest that the authors consider a more qualitative approach throughout the report and SPM in particular and describe the key results of their analysis in the SPM (e.g. Where are the major barriers? Where are conditions right for rapid transformations?) and signpost the more in depth discussion and analysis in the chapters where the nuances of the findings can be addressed.	Government of United Kingdom (of Great Britain and Northern Ireland)	United Kingdom (of Great Britain and Northern Ireland)	Thank you for your comment. There is no figure on feasibility in the approved SPM
19063	1	1	5000	70	The sector chapters (6-11) treat the different sectors quite differently. For example, the transport and industry chapters have less overarching pathway detail, and take a more technology specific approach. Whereas energy and buildings both have a fairly substantial section on future scenarios, including referring to IEA and others, which is useful. Whilst we understand that these differences are driven, to a certain extent, by the availability of evidence, could the CLAs be encouraged to review their approaches in light of the best developments across the sector chapters and consider doing what is possible to maximise consistency?	Government of United Kingdom (of Great Britain and Northern	United Kingdom (of Great Britain and Northern Ireland)	Noted. Thanks
19065	1	1	5000	70	We are concerned that the groupings of countries used throughout the report, be that regionally or along developed/developing-type lines, is not logical, consistent or transparent. It needs to be clear why specific groupings have been used (ideally showing that the groupings are representative of their members), that they can be compared with other analyses (particularly within the WGIII report but also across all the WG reports and aligned with the UNFCCC) and it must be obvious which countries are in groups when they are used.	Government of United Kingdom (of Great Britain and Northern	United Kingdom (of Great Britain and Northern Ireland)	Noted, thank you for your comment. The regional classification is now clarified in Annex II of the report.
37317	1	1	1	1	A few select authors who are also lead authors/contributing authors in the Draft Report are referred to in extraordinary numbers and an extraordinary number of their papers are cited. This severely detracts from the credibility of the Report in terms of objectivity and that it represents a critical scientific assessment as required. Some key examples are the following: Elmar Kriegler , 140 papers/reports cited, cited 80 times in the Report. Corresponding numbers for others are Keywan Riahi (140,83), Detlef Van Vuuren (168,91), Rogelj (144,81) and Brian O'Neill (70,80). All references to be reviewed independently (excluding these authors) by other lead/contributing authors on a blind referee basis and required changes to be undertaken for a suitable objective assessment	Government of India	India	Noted - the IPCC proces includes extensive review at all stages
50457	1	1	1	1	Some of the chapters might be too lengthy, suggest including only literature reviews which are keys, e.g. any different "what if" with or without such info?	Hoy Yen Chan	Malaysia	Noted
61231	1		63		Negative emissions technologies related evaluation is not sufficient, the assessment of the link between adaptation and mitigation of climate change is insufficient, the link with the relevant part of the WG2 report, and the link with the relevant content of the SRCCL (IPCC 2019) are not sufficiently assessed. The impact of different mitigation measures on biodiversity and the environment Insufficient impact, etc., need to further fully evaluate these parts	Jianguo WU	China	Noted. Chapter 3 has been completely revised and most of the issues raised here are now also being addressed.
75167	1	1	700	1	Thanks to all the authors and leaders of WGIII for their work on this report. It an important report and valuable resource.	Government of Ireland	Ireland	Thank you for the postive comment
75169	1	1	700	1	The attention given to link with WGI material is very welcome as are the links to WGII which are clearly part of climate actions in practice. Clarity on these is very important and some further development of these may be needed.	Government of Ireland	Ireland	Thank you for the postive comment
82559	1	1	1	1	Reviewer Group: World Nuclear Association Point of Contact: Jonathan Cobb jonathan.cobb@world-nuclear.org Reviewers Sama Bilbao y Leon, Director General, World Nuclear Association Jonathan Cobb, Senior Policy Advisor, World Nuclear Association David Hess, Policy Analyst, World Nuclear Association King Lee, Director Harmony Programme, World Nuclear Association	Jonathan Cobb	United Kingdom (of Great Britain and Northern Ireland)	Noted
83537	1	1	1	1	I strongly support the choice to cover the greenhouse gas metric discussion in appropriate technical depth in Box 2.2 and the TS, but not elevate it to the SPM. At the same time, some sections of Annex B on greenhouse gas metrics do currently not provide a balanced assessment and discussion of this topic. Some paragraphs cite literature only partially, repeat point, and at times read like fan letters for novel metrics. The discussion in Annex B should still be significantly improved for balanced and accuracy, ensuring that a robust assessment is presented.	Joeri Rogelj	United Kingdom (of Great Britain and Northern Ireland)	Thank you, Annex B has been reduced to provide factual information about the choice of GWP-100 as default metric in the WGIII report only. Additional detail supporting our assessment is now provided as supplementary material to chapter 2, and we have taken comments on board to ensure balance of this material and supplement the core assessment contained in Cross-Chapter Box 2.2

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86511	1	1	1	1	The Report does an excellent job of covering a very wide range of the many components of the climate change complex problem. It is evident that, as stated in the SPM, there is a "Broader and more diverse analytic frameworks and multiple disciplines." This, together with the literature orientation of the Report, is interesting but I think sometimes a better effort could have been provided to 1) Always contextualise pieces of literature in areas often very distant from one another 3) Harmonize such distant areas one with another and against the background of the main description of the climate problem, which is ultimately science-driven. Some areas I found particularly relevant to this and recurring, hopefully consistently, in my Comments are the approach and definition of Just Transition, the definition of trade-offs with SDGs and Adaptation. Thank you	Lorenzo Campus	United States of America	Noted. thanks
19541	4	13	4	17	This comment is on the Glossary (which cannot be selected in the dropdown list): Please revise "Carbon capture and storage (CCS) from industrial ... with bioenergy production (BECCS)." as follows: "Carbon capture and storage (CCS) from point-source emissions, only removes CO2 from the atmosphere to the extent to which the CO2 is either of biogenic (e.g. bioenergy- or biomass waste treatment) or atmospheric origin (directly captured from the atmosphere)."	Matthias Honegger	Germany	Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.
45661	4	0			Glossary, Annex A, page 4, Anthropogenic removals: Please adjust the definition of BECCS to include the need for sustainability. "Carbon capture and storage (CCS) from industrial and energy-related sources, which alone does not remove CO2 from the atmosphere, can help reduce atmospheric CO2 if it is combined with sustainable bioenergy production (BECCS)." please see https://onlinelibrary.wiley.com/doi/10.1111/gcbb.12798.	Government of Germany	Germany	Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.
19543	7	45	7	55	This comment is on the Glossary (which cannot be selected in the dropdown list) for the entry on CCU: Add: " …Only then, and only combined with CO2 recently removed from the atmsphere (stemming from biogenic carbon or direct air carbon capture), can CCUS .... "	Matthias Honegger	Germany	Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.
45663	7	0	8	0	Glossary, Annex A, page 7/8, definition of CDR: The current definition excludes "natural CO2 uptake not directly caused by human activities". This definition is very narrow and could be interpreted as to limit CDR approaches to technological options. We therefore kindly request to modify the CDR definition as follows: "Anthropogenic activities removing carbon dioxide (CO2) from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products. It includes existing and potential anthropogenic enhancement of biological or geochemical CO2 sinks and direct air capture and storage. Enhancement of biological sinks includes restoration and management of ecosystems, but excludes natural CO2 uptake not caused by human activities."	Government of Germany	Germany	Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.
85913	8	0	8	0	Glossary A - Is there a reason why authors have not included a definition of Climate neutrality, as defined in the Special Report, Global warming of 1.5 degrees?	Government of Australia	Australia	Thank you for your comment. The term 'climate neutrality' is not used in the underlying chapters, and so has not been defined in the glossary.
85915	8	0	8	0	Glossary A - Is there a reason why the definition of Carbon neutrality is narrowly defined? Suggest authors also review the use of this term through the report for consistency.	Government of Australia	Australia	Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definition of Carbon Neutrality is consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.
3549	9	5	9	5	In Annex A: Glossary, page A - 9, after carbon stock definition, please add a new definition: "Carbonation Hydrated cement used in concrete or mortars naturally absorbs carbon dioxide during its lifetime, a physicochemical process known as carbonation, thus removing carbon from the atmosphere. This permanently locks carbon dioxide, providing a stable long-term carbon dioxide storage solution. The process can even boost concrete strength by increasing the density of its pore structure. (CEMBUREAU 2020; Sanjuán et al 2020; Andrade and Sanjuán 2018) See also Recarbonation". CEMBUREAU 2020. https://lowcarboneconomy.cembureau.eu/5-years-on/the-5c-approach/recarbonation/ Sanjuán, M.Á.; Andrade, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake by Cement-Based Materials: A Spanish Case Study. Appl. Sci. 2020, 10, 339. https://doi.org/10.3390/app10010339 Andrade C, Sanjuán MA. Updating Carbon Storage Capacity of Spanish Cements. Sustainability 2018;10:4806.	Miguel Angel Sanjuán	Spain	Rejected. Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.

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10441	9	5	9	5	In Annex A: Glossary, page A - 9, after carbon stock definition, please add a new definition: "Carbonation Hydrated cement used in concrete or mortars naturally absorbs carbon dioxide during its lifetime, a physicochemical process known as carbonation, thus removing carbon from the atmosphere. This permanently locks carbon dioxide, providing a stable long-term carbon dioxide storage solution. The process can even boost concrete strength by increasing the density of its pore structure. (CEMBUREAU 2020; Sanjuán et al 2020; Andrade and Sanjuán 2018) See also Recarbonation". CEMBUREAU 2020. https://lowcarboneconomy.cembureau.eu/5-years-on/the-5c-approach/recarbonation/ Sanjuán, M.Á.; Andrade, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake by Cement-Based Materials: A Spanish Case Study. Appl. Sci. 2020, 10, 339. https://doi.org/10.3390/app10010339 Andrade C, Sanjuán MA. Updating Carbon Storage Capacity of Spanish Cements. Sustainability 2018;10:4806.	Aniceto Zaragoza	Spain	Rejected. Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.
11597	9	5	9	5	In Annex A: Glossary, page A - 9, after carbon stock definition, please add a new definition: "Carbonation Hydrated cement used in concrete or mortars naturally absorbs carbon dioxide during its lifetime, a physicochemical process known as carbonation, thus removing carbon from the atmosphere. This permanently locks carbon dioxide, providing a stable long-term carbon dioxide storage solution. The process can even boost concrete strength by increasing the density of its pore structure. (CEMBUREAU 2020; Sanjuán et al 2020; Andrade and Sanjuán 2018) See also Recarbonation". CEMBUREAU 2020. https://lowcarboneconomy.cembureau.eu/5-years-on/the-5c-approach/recarbonation/ Sanjuán, M.Á.; Andrade, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake by Cement-Based Materials: A Spanish Case Study. Appl. Sci. 2020, 10, 339. https://doi.org/10.3390/app10010339 Andrade C, Sanjuán MA. Updating Carbon Storage Capacity of Spanish Cements. Sustainability 2018;10:4806.	PEDRO MORA PERIS	Spain	Rejected. Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.
72409	10	37	10	37	On the entire report (e.g. Chapter 2): I'm not sure what precisely to comment on this chapter two, or even most of the following ones: Is the analysis that for example Garrett et al. (2020) conduct, on growth, carbonization rates, and the constant scaling of primary energy consumption with the time integral of economic production foundational? It should be possible to mention, critique or discuss the implications of this analysis, in this and the other chapters of the report—but if mentioned, doesn't this call for reanalyzing many basic assumptions in current models and the literature, not least on the role of energy efficiency and necessary conditions for decarbonization? It may not apply necessarily to regional or sectoral analysis, given complexity and data constraints, but without such a physically grounded global framework (of civilization as a thermodynamically open complex system), global argument seems incomplete. Add reference: Garrett, Timothy J, Matheus R Grasselli, and Stephen Keen. 2020. “Past Production Constrains Current Energy Demands: Persistent Scaling in Global Energy Consumption and Implications for Climate Change Mitigation.” PLoS ONE (August 27): 1–19. 10.1371/journal.pone.0237672.	Paul Maidowski	Germany	Noted
45665	15	1	15	1	Glossary, Annex A, page 15: The following definitions should be included: EbA and Ecosystem approach as follows: "Ecosystem-based adaptation (EbA) is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change. EbA aims to maintain and increase the resilience and reduce the vulnerability of ecosystems and people in the face of the adverse effects of climate change.” (SCBD 2009). The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. Thus, the application of the ecosystem approach will help to reach a balance of the three objectives of the Convention: conservation; sustainable use; and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. An ecosystem approach is based on the application of appropriate scientific methodologies focused on levels of biological organization, which encompass the essential structure, processes, functions and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of many ecosystems. CBD secretariat (2004) CBD Guidelines The Ecosystem Approach. Secretariat of the Convention on Biological Diversity, Montreal, Canada. https://www.cbd.int/doc/publications/ea-text-en.pdf	Government of Germany	Germany	Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.

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61283	32				This comment refers to the Glossary Mitigation The IDMP glossary follows the IPCC 2012 definitions of mitigation which acknowledged the existence of different definitions amongst the technical community for disaster risk reduction as compared to the international climate change community, as follows: Mitigation (of disaster risk and disaster): The lessening of the potential adverse impacts of physical hazards (including those that are human-induced) through actions that reduce hazard, exposure, and vulnerability. Mitigation (of climate change): A human intervention to reduce the sources or enhance the sinks of greenhouse gases. The Disaster Management community defines mitigation (UN 2016): Mitigation: The lessening or minimizing of the adverse impacts of a hazardous event. Annotation: The adverse impacts of hazards, in particular natural hazards, often cannot be prevented fully, but their scale or severity can be substantially lessened by various strategies and actions. Mitigation measures include engineering techniques and hazard-resistant construction as well as improved environmental and social policies and public awareness. It should be noted that, in climate change policy, “mitigation” is	Graham von Maltitz	South Africa	Noted
85583	32		32		Mitigation measures: Definition of mitigation measure 'In climate policy, mitigation measures are technologies, processes or practices that contribute to mitigation, for example renewable energy technologies, waste minimisation processes, and public transport commuting practices.' seems to be requred more clear clarification.	San Win	Myanmar	Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definition of mitigation measure is consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.
19545	33	60	33	65	Please revise definition of NDC as follows: "A term used under the United Nations Framework Convention on Climate Change (UNFCCC) whereby a country that has joined the Paris Agreement outlines its plans toward the mitigation of climate change. Some countries' NDCs also address how they will adapt to climate change impacts, and what support they need from, or will provide to, other countries to adopt low-carbon pathways and to build climate resilience." Reason: The definition needs to be aligned with the origin of the provision (in UNFCCC decision 1/CP.19) that directly refers to the Convention's Art. 2, which states the UNFCCC's objective to be focussed on the "...stabilization of greenhouse gas concentrations in the atmosphere..." The stated scope of NDCs thus is on the "mitigation of climate change" (and not limited to "emissions reductions")	Matthias Honegger	Germany	Noted. Thanks
45667	34	1	34	1	Glossary, Annex A, page 34: Net negative greenhouse gas emissions: A situation of net negative greenhouse gas emissions is achieved when metric-weighted anthropogenic greenhouse gas (GHG) removals exceed metric-weighted anthropogenic GHG emissions. Where multiple GHG are involved, the quantification of negative emissions depends on the metric chosen to compare emissions of different gases (such as global warming potential, global temperature change potential, and others, as well as the chosen time horizon) COMMENT: In the first sentence the term 'anthropogenic greenhouse gas removal' is used, in the second 'negative emissions' to address the greenhouse gases which are being removed from the atmosphere. This is confusing as the definition of GGR differs from the definition of net negative emissions. Please harmonize the used terms and make sure that the definition also includes CO2 uptake caused by restoration and management of ecosystems	Government of Germany	Germany	Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.
45669	37	0			Glossary, Annex A, page 37: Pathways: We urge the authors to describe the difference of "pathway" and scenario" since these are often used interchangeably, e.g., "overshoot scenarios" and "overshoot pathway", or for 1.5°C, low carbon, or RCP and SSP which are both pathways and scenarios. Also, please define "development scenario/pathway". It would be very useful indeed if the IPCC could come up with clear definitions of these terms and use them consistently across the AR6.	Government of Germany	Germany	Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.
3551	39	17	39	17	In Annex A: Glossary, page A - 39, after Rebound effect definition, please add a new definition: "Recarbonation Concrete or mortars naturally absorbs carbon dioxide during its lifetime, removing carbon from the atmosphere and permanently locking carbon dioxide. This process provides a stable long-term carbon dioxide storage solution. During the life of a built structure, up to 25% of the process emissions related to the production of the cement can be absorbed (CEMBUREAU 2020; Sanjuán et al 2020; Andrade and Sanjuán 2018) See also Recarbonation". CEMBUREAU 2020. https://lowcarboneconomy.cembureau.eu/5-years-on/the-5c-approach/recarbonation/ Sanjuán, M.Á.; Andrade, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake by Cement-Based Materials: A Spanish Case Study. Appl. Sci. 2020, 10, 339. https://doi.org/10.3390/app10010339 Andrade C, Sanjuán MA. Updating Carbon Storage Capacity of Spanish Cements. Sustainability 2018;10:4806. https://doi.org/10.3390/su10124806	Miguel Angel Sanjuán	Spain	Rejected. Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.

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10443	39	17	39	17	In Annex A: Glossary, page A - 39, after Rebound effect definition, please add a new definition: "Recarbonation Concrete or mortars naturally absorbs carbon dioxide during its lifetime, removing carbon from the atmosphere and permanently locking carbon dioxide. This process provides a stable long-term carbon dioxide storage solution. During the life of a built structure, up to 25% of the process emissions related to the production of the cement can be absorbed (CEMBUREAU 2020; Sanjuán et al 2020; Andrade and Sanjuán 2018) See also Recarbonation". CEMBUREAU 2020. https://lowcarboneconomy.cembureau.eu/5-years-on/the-5c-approach/recarbonation/ Sanjuán, M.Á.; Andrade, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake by Cement-Based Materials: A Spanish Case Study. Appl. Sci. 2020, 10, 339. https://doi.org/10.3390/app10010339 Andrade C, Sanjuán MA. Updating Carbon Storage Capacity of Spanish Cements. Sustainability 2018;10:4806. https://doi.org/10.3390/su10124806	Aniceto Zaragoza	Spain	Rejected. Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.
11599	39	17	39	17	In Annex A: Glossary, page A - 39, after Rebound effect definition, please add a new definition: "Recarbonation Concrete or mortars naturally absorbs carbon dioxide during its lifetime, removing carbon from the atmosphere and permanently locking carbon dioxide. This process provides a stable long-term carbon dioxide storage solution. During the life of a built structure, up to 25% of the process emissions related to the production of the cement can be absorbed (CEMBUREAU 2020; Sanjuán et al 2020; Andrade and Sanjuán 2018) See also Recarbonation". CEMBUREAU 2020. https://lowcarboneconomy.cembureau.eu/5-years-on/the-5c-approach/recarbonation/ Sanjuán, M.Á.; Andrade, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake by Cement-Based Materials: A Spanish Case Study. Appl. Sci. 2020, 10, 339. https://doi.org/10.3390/app10010339 Andrade C, Sanjuán MA. Updating Carbon Storage Capacity of Spanish Cements. Sustainability 2018;10:4806. https://doi.org/10.3390/su10124806	PEDRO MORA PERIS	Spain	Rejected. Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.
61285	46				The definition of Sustainable land management refers to The stewardship and use of land. This is excellent. There is no definition of stewardship provided in the glossary and not particular consideration given to this in the report. The report includes a chapter on the use of land (AFOLU) and a tradeoffs chapter. It would be good to add more on the stewardship of land.	Graham von Maltitz	South Africa	Rejected. The glossary includes terms that are applied by more than one chapter in the WG III AR6 report.
72407	46	25	46	25	On the entire report (e.g. Chapter 1): I the literature on biological & complexity could strengthen analysis, particularly for thermal intolerance of life and ecosystems (incl. to the short-term effect of unmitigated loss of aerosol (masked) forcing). This seems one of the big questions to address in the entire report to accurately reflect dynamics, given the urgent necessity to avoid thermal overshoot that would be detrimental to entire species and ecosystems. A systematic focus on ecological and biophysical literature in the entire WG3 work would help and lend a vitally important perspective of real-life constraints to analysis. This closely matches the recommendation to reflect thermodynamic perspectives (Garrett et al. 2020, Bardi 2019, Tainter 1988) that I'd enourage introducing systematically. But I wouldn't know where to start addressing it here, given the advanced stage of the review. While it would be good to strengthen the argument in all chapters, maybe a focus on particularly pertinent questions is still feasible? This would seem to require cross-chapter planning and coordination. Maybe the most lethal and systemic oversights, including potential gaps between WG1 and WG3 assumptions, can be addressed in time.	Paul Maidowski	Germany	Noted
155					The report would benefit from a Table of Acronyms. This would aid legibility otherwise text easily becomes meaningless.	TIMOTHY BARKER	United Kingdom (of Great Britain and Northern Ireland)	Thank you for you comment. A list of acronyms will be provides during final publication

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Comment ID	From Page	From Line	To Page	To Line	Comment	Reviewer	Country	Chapter Team Response
1505					I will begin with some comments and strong recommendations that apply to the entire report, in principle. In summary, I think you have a very big problem with the SOD, but I have proposed a very simple solution that could lead to a much more honest, clear, and truthful report. In its current form, there are many statements, tables and figures that are simply not true and/or no longer valid. 1.Except for very limited exceptions, the climate mitigation literature that was extensively referenced and used to support the October 2018 Special Report on 1.5 degree C Scenarios can no longer be relied on in this report. This is especially true for data from the hundreds of outputs from integrated assessment models that were produced prior to 2018, and that we utilized in writing that report. There are two major reasons why it would be deceptive and pointless to continue to refer to and utilize those results in your AR6 report. First of all, the WGIII has already said what it wanted to say about the relevance of that extensive literature on mitigating climate change in the October 2018 Special Report, so no one will learn anything new by continuing to utilize that literature yet again. Second of all, that literature and the integrated assessment model results that it relied on is by now COMPLETELY OUT OF DATE and is, therefore, not valid! In fact, as you know, I argued even in the time period 2017-18 in letters to you and the IPCC that that pre-2018 literature and the pre-2018 IAM results were even out of date by the time they were utilized in the Special Report, and should not have been used even then. One reason those runs made before 2018 were all out of date is because they all utilized real discount rates in the 3-5% range, with most assuming 5%. Using such real high discount rates was insane even then, as I and others argued to you and the IPCC in letters we sent you in September 2017, when the Special Report was being drafted. Such high discount rates completely distort the efficacy of using cost effectiveness methodologies in IAMs, and provide no use at all to climate change policy makers. They bias results in favor of investments in negative emissions technologies after 2050. Thus, only literature on the mitigation of climate change that was published AFTER the Special Report was published in 2018 should be utilized in this AR6 report, since at least that newer literature might provide some new insights into relevant issues if it was based on reasonable assumptions. 2.Given that world-wide interest rates are now even lower than they were in 2018, and given that moral arguments that are still valid support the use of very low or 0% real discount rates, no economic analyses of mitigation using a real discount rate of higher than 1% should even be considered to be included in this AR6 report. Note that most central banks have nominal interest rates in the 0% range, and net of inflation they are in the -1% or -2% range in real terms as used for discount rates in IAMs. Even the 30 year US treasury bonds only pay about 2% interest now, which is less than 1% in real terms net of inflation. Governments and private corporations can both borrow money much more cheaply than they could when the IAM runs referenced in the SOD were made. Since the choice of an appropriate real discount rate for any economic analysis or model run is the MOST IMPORTANT CHOICE NEEDED TO BE MADE FOR ANY VARIABLE, the use of an improper and out of date real discount rate would alone disqualify any economic analysis or IAM run from included in the SOD. 3.However, even worse for considering referencing any IAM results at all in this new AR6 report is that they are also (probably all) out of date in most of the key cost input assumptions they make for new energy supply technologies, especially renewable electricity technologies such as solar photovoltaics and wind. Since in any reasonable and interesting mitigation scenario these new technologies will play a major role in providing zero carbon electricity in the future, it is critical that the cost assumptions for these technologies be up to date if you want policy makers to take economic analyses of these technologies seriously. However, as the graphs in the SOD show explicitly, and as everyone in this field of study knows, the capital costs of these key technologies, and other highly relevant technologies such as electric vehicles, have been plummeting	Richard Rosen	United States of America	Noted. Chapter 3 has been completely revised and most of the issues raised here are now also being addressed.
1687					Most of the figures are not clear.	Sunday Abuje	Kenya	High resolution figures are added in the final version
1689					A section dedicated to urban climate adaptation is necessary. The foremost challenge facing urban areas in the developing world is managing the impacts of climate change as opposed to mitigation since a majority of those urban areas do not even reach the emission quotas allocated.	Sunday Abuje	Kenya	Accepted. There is a cross-working group box on integrating urban mitigation and adaptation.
3417					This is an excellent draft at this stage of the process. The transition from Chapters to Technical Summary (TS) to Summary for Policymakers (SPM) is done very well. I sense that the SPM is running ahead of the Chapters to set the stage for the next Assessment. I will like to offer some comments from the perspective of someone who has not been following the WG III process very closely. (1)The first sentence in the SPM says: "The Working Group III (WG III) contribution to the IPCC's Sixth Assessment Report (AR6) assesses literature on the scientific, technological, environmental, economic and social aspects of mitigation of climate change." I found very little materials on the scientific , technological and environmental aspects in the SPM. With the pathways approach, it would seem that the emphasis is now on economic and social aspects. While I do not disagree with the approach, a brief explanation would be helpful. The implicit message I got is that the world does not have to wait for new technologies to act. (2)I had a chance to look at the SOD for WG II report earlier. I did not see a clear explanation of how the followings fit together: the 17 SDGs, the 17 Decent Living standards (Figure TS.30), various mitigation options, the Illustrative Pathways, and the 24 adaptation options from WG II. (3)Going forward, it will be a challenge to harmonize the roles of WGII and WGIII on how mitigation and adaptation play together to minimize climate impacts through use of technology and choice of pathways to meet the SDG. Previously, my understanding was that the charge to WGIII is narrowly defined as assessing "options for mitigating climate change through limiting or preventing greenhouse gas emissions and enhancing activities that remove them from the atmosphere". A lot more emphasis is now given to the following: " The WG analyses the costs and benefits of the different approaches to mitigation, considering also the available instruments and policy measures. The approach is more and more solution-oriented."	Malcolm Ko	United States of America	Thank you. Noted and revised
4099					Throughout the report, frequently mentioned terms like "greenhouse gas" should be almost totally abbreviated as GHG to save space (see, for instance Chapter 2, p.12), whilst sparsely mentioned words may be cited in full at a first appearance in a section or a sub-section to help readers, since it is inconvenient to refer to the list of abbreviation every time it appears.	Tatsuki Ueda	Japan	Noted. Thank you.
4867					Another great piece of work by IPCC authors. Builds nicely on all that's gone before. Congratulations.	Harry Saunders	United States of America	Thank you
8151					Please do not mix LULUCF and AFOLU. At various places in the report, reference is made to "forestry and other land-use change". This is just plain wrong by definition (forestry is land management, not a change in its use). In the concept of AFOLU land-use change is incorporated and not named separately. This comment may look like nit-picking, but not getting the basics straight raises concerns about the analyses based hereon, and also about the competence of the authors - you do not want this, I assume.	Joachim Rock	Germany	Noted, thanks

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8185					Please avoid using acronyms in table headings and figure sub-texts that are not given in full in the same header / sub-text.	Joachim Rock	Germany	Noted, thanks
8771					Pastoralism is barely mentioned in the report. Sustainable pastoralism has been identified as a viable socioeconomic system that, if implemented effectively, actively supports ecosystems, increases biodiversity, reverses land degradation, and mitigates GHG emissions (Niamir-Fuller & Huber-Sannwald, 2020). Considering pastoralism is carried out by more than 200 million people worldwide, on every continent, (Dong, 2016) they need to be taken seriously as a viable pathway to sustainable development. Niamir-Fuller, M., & Huber-Sannwald, E. (2020). Pastoralism and Achievement of the 2030 Agenda for Sustainable Development: A Missing Piece of the Global Puzzle. In Stewardship of Future Drylands and Climate Change in the Global South (pp. 41-55). Springer, Cham. Dong, S. (2016). Overview: Pastoralism in the world. building resilience of human-natural systems of pastoralism in the developing world, 1-37.	Billy Jones	Sweden	Noted, thanks
9293					Many of the FAQs use acronyms without spelling them out. Please make sure even readers with little background knowledge get the meaning of these technical abbreviations. In journalism, acronyms are usually spelled out when they are used for the first time in a text, and the acronym is provided (introduced) in brackets. I would suggest to follow this practice and treat each FAQ as an individual text.	Maike Nicolai	Germany	Noted. Chapter 3 has been completely revised and most of the issues raised here are now also being addressed.
9295					The WGIII FAQs are much shorter than the ones from WGI and WGII. In my impression, they sometimes seem to function as "teasers" that refer readers to certain sections of the report. Unfortunately, those "teasers" are phrased rather technically and do not seem to aim to help readers understand key aspects of the report - which I think is one of the goals of the WGII and WGI FAQs. To increase the impact of the IPCC FAQs in the future, their purpose and style could be harmonised across Working Groups.	Maike Nicolai	Germany	Thank you for your comment. Noted.
9799					There should be a footnote in each chapter of the IPCC reports on the criteria that are being used to define a phenomemon or scenario as a low confidence, medium confidence and/or high confidence one. In my view, a scenario should be a low-confidence scenario if it is supported by the findings of at least 5 Q1/Q2 research articles; a scenario should be a medium-confidence scenario if it is supported by the findings of at least 20 Q1/Q2 research articles; and to be a high-confidence scenario, IPCC should assess a medium-confidence scenario or assign a group of scentific experts to reach a consensus on the same.	A M Mabrur Ahmad Rashedi	Australia	Rejected. Thank you for your comment. For confidence statements, IPCC uses "Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties" by Mastrandrea et al. (2010): https://www.ipcc.ch/site/assets/uploads/2017/08/AR5_Uncertainty_Guidance_Note.pdf
12787					The use of the term "offset" can create an impression that emissions can be cancelled out by e.g. afforestation projects. This is misleading since carbon from fossil sources cannot be equated with removal using nature based solutions. As Skelton 2020 has pointed out, we need all available nature based solutions to help mitigate carbon already emitted. This leaves no room for using such solutions for also helping to offset "hard to reduce" emissions. Such emissions will have to be counted as emissions, without discussing how they can be offset. Only then can we see them for what they are - truly problematic. Reference: Skelton, A., 2020. Bolin Centre Climate Arena Policy Brief November 2020 - Making an educated decision about Carbon offsetting. Bolin Centre for Climate Research.	Flora Hajdu	Sweden	Thank you for your comment. Noted
24781					We would like to thank the authors for providing this second order draft report and first order SPM despite the extremely difficult circumstances we all face due to the COVID pandemic. Your efforts are much appreciated since there will never be a vaccine against climate change. Thanks again for your great work!	Government of Estonia	Estonia	Thank you for your postive comment
39039					My general coment is theat the report does a very good job of discussing risks arising from physical impacts and in terms of a range of social risks. Where there should be further effort is in terms of a broader range of risks--pareticularly, transition risks (both adaptation and mitigation) risks to firms and governments. The chapters on individual economic sectors would benefit from much deeper risk analysis than they seem to be receiving here.	Robert Buhr	United Kingdom (of Great Britain and Northern Ireland)	Thanks, noted
43029					In my comments, I will argue that many of the AR6 WGIII findings are not adequately presented in the Summary for Policymakers. The WGIII report points out that while greatly accelerated reductions in emissions are needed, proposed mitigation efforts (e.g. rapid reductions supported by CCS and BECSS) may not be feasible and/or may not be implemented in time and at the scale required to prevent overshoot. Missing from the report is a proposal for addressing the critical question of whether Paris Agreement targets can and will be met with current commitments and plans, and if not, what must be done to keep global temperatures from reaching levels that could cause catastrophic and irreversible damage.	Graeme Taylor	Australia	Thanks, noted
43031					Climate change is a risk management problem. It requires a comparative assessment of the likely risks and costs of acting or not acting to prevent undesirable impacts. As a consequence a section needs to be added to the report describing likely risks and how they can be managed.	Graeme Taylor	Australia	Noted
43033					Major risks are (a) Even if all national commitments are met and technological breakthroughs accelerate the transition to emission-free technologies, the Paris targets are likely to be overshot due to systemic inertia from existing greenhouse gases, warming oceans, and the decades required to replace existing infrastructure. (b) Although most scenarios require the large-scale deployment of climate geoengineering, many methods may not be politically and/or technologically feasible; (c) While most scenarios assume climate overshoot will occur before safe climates are re-established, many human and environmental systems cannot adapt to higher temperatures. Temperatures likely to cause catastrophic and/or irreversible damage pose unacceptable risks.	Graeme Taylor	Australia	Thank you. Some of these issues are being taken care of.
43035					The WGIII report correctly emphasises that rapidly reducing emissions is cheapest and safest mitigation option. However, given that climate overshoot is likely, and that it cannot be prevented without large-scale geoengineering, knowledge gaps need to be urgently filled on all mitigation options. A critical issue is that while CDR methods are safer than SRM, they will act too slowly to prevent dangerous overshoot, and it may be necessary to also deploy SRM to shave peak temperatures. The WGIII report should add a section recommending prioritising research both on climate overshoot risks, and on the relative effectiveness, risks, costs and timelines of potential mitigation methods. This research is a prerequisite for evaluating the comparative benefits, costs and risks of using, or not using, various forms of mitigation.	Graeme Taylor	Australia	Noted

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43295					Overall I find the report excellent in content and improved over the first order draft. Well done to the authors.	Jeffrey Seale	United States of America	Thank you for your positive comment
48519					Include a dedicated acronyms and abbreviations section that is listed in the table of contents.	Kathleen Araujo	United States of America	Noted. List of acronyms will be provided for the report as a whole before publication
49769					Consider a Cross-Report Box that speaks to the role that Indigenous People's knowledge, laws and governance can contribute to climate science, mitigation, and adaptation. The IPCC has taken steps to incorporate Indigenous people in the AR6, but there is room for improvement. A Cross-Report Box could provide greater visibility and recognition of inherent Indigenous rights, Indigenous rights as recognized by international law (UNDRIP), and climate justice. Identify the need for including Indigenous knowledge, traditional knowledge, and Indigenous science in global climate science, mitigation and adaptation strategies. Recognize Indigenous voices who have been calling for systemic change and a paradigm shift away from polluting economies for centuries. Recognize the reciprocal relationship Indigenous people have had with the earth for millenia, and how biodiversity is best protected and enhanced in areas managed by Indigenous people. Showcase global Indigenous leadership in climate governance and climate diplomacy	Chloe Hartley	Canada	Partially accepted. Chapter 7 includes case studies on more inclusive resource management approaches that integrate indigenous knowledge can deliver multiple benefits. The role of indigenous people in adaptation is adequately addressed in the WGII report (Impacts and Adaptation) of the IPCC
49771					Consider the use of a Cross-Chapter Box to address inherent Indigenous rights, Indigenous knowledge (IK), Indigenous science, and climate justice. Emphasize the importance of establishing IK as a line of evidence, and the importance of providing space for Indigenous voices in IPCC reports in alignment with the Indigenous peoples platform. Please consult directly with Indigenous organizations and Indigenous scholars actively working on the proper collection, use, and treatment of IK. Datapoints cannot be extracted from Indigenous Knowledge to inform climate models, for example, in the same way 'western' science is treated. We have chosen to use IPCC language here to suggest using Indigenous Knowledge as a distinct "line of evidence". The intent of this comment suggests Indigenous Knowledge is to be treated with equal weight in parallel with 'western' science. Two Eyed Seeing is an accessible understanding of this concept; however, applying Two Eyed Seeing in this context has complex subtleties	Chloe Hartley	Canada	Noted. Thank you for this important point. Chapters in teh current draft do touch upon this important aspect. Also to note the IPCC WGII report covers this in much more detail.
49773					The COP has recognized the necessity of including Indigenous knowledge and practices when addressing and responding to Climate Change. The Local Communities and Indigenous Peoples platform was established in part to facilitate the meaningful and holistic integration of knowledge, laws, governence models, technologies, practices and efforts of local communities and Indigenous Peoples into the UNFCCC process. Consequently, it is disapointing to see a lack of integration and recognition of Indigenous knowledge, laws,and governance and well as consideration of the role of Indigenous Peoples across AR6 WG reports. The IPCC should be responding to the COP by ensuring that Indigenous knowledge is more substantively represented in all future reports	Chloe Hartley	Canada	Noted. Thank you for this comment. Some of these issues are covered in the AR6 WGII report including the vulnerability to future climate as well as recognising their important role in sustainable development
49775					When listing key actors on the global stage and key sources of policy, knowledge, agreements, the report must include references to Indigneous Nations, Indigenous knowledge, laws and governance, in alignment with UNDRIP principles. First Nations in the U.S. are developing Climate Diplomacy alliances with other First Nations to ensure a voice for Indigenous People in mitgating climate change. The UN is one realm that formally recognises the rights of Indigenous Peoples and these reports should be integrating this recognition and role in all sections.	Chloe Hartley	Canada	Accepted. Revised
49777					Indigenous Peoples are leaders in climate activism around the planet. Indigenous Peoples have been fighting to protect their lands, forests and waterways, they are fighting to stop oil and gas infrastructure from being built and fighting to restore impacts from oil and gas extraction. Hundreds of Indigenous leaders have been murdered and continue to be murdered for doing this work. The impacts of climate change disproportionally effect Indigenous people. Indigenous Peoples are the original climate champions and arguably have made the most substantive gains in raising awareness for climate mitigation, in protecting natural assets like forests and wetlands, and in slowing the development of oil and gas infrastructure. In Canada many First Nations have been early adapters of solar power and green building methods. Despite these achievements, the work, the ideas, the knowledge, the laws and governance models of Indigenous people have largely been ignored in this report. The IPCC Secretariat must engage more directly with Indigenous organizations such as ours that are driving the good work for the planet. This report must integrate and acknowledge the work of Indigenous peoples as one of the few effective models for achieving policy change and slowing the development of new oil and gas infrastructure	Chloe Hartley	Canada	The IPCC mandate it to review all available literature relevent to climate mitigation. IPCC encourages academics and practitioners from all backgrounds to fill gaps in the literature in order that that this valuable insights can be included in IPCC reports. Indigenous Peoples can also play an valuable role as authors, reviewers in the IPCC and we would encourage their nomination
49779					Climate mitigation must integrate UNDRIP in analysis, strategy, and response. UN Committee on the Elimination of Racial Discrimination (CERD) specifically rebuked Canada for failing to respect international law (UNDRIP) by proceeding with the Trans Mountain pipeline expansion project, the Coastal Gaslink project, and the Site C dam, without first recieving free, prior and informed consent of Indigenous Peoples. The main purpose of these three projects is to facilitate the oil and gas industry. Had UNDRIP been respected in Canada, these climate harming projects might not have been approved	Chloe Hartley	Canada	Noted
51285					How balanced is the board of (lead) authors of the report? It would be helpful to publish these details, e. g. in terms of gender, nationality, cultural background etc, if not available already.	Stefanie Kunkel	Germany	This information is available on the IPCC website
51287					The form to comment the report is a Microsoft Excel sheet per default. Open formats/software should be used to enable broader participation of reviewers.	Stefanie Kunkel	Germany	noted
53713					The resolution of some charts is low. It is recommended to further improve the clarity of the chart and standardize the picture labeling (for example, modify "2oC" in Figure TS.5 Figure b on page TS-3-15 to "2°C").	ZHENG XINZHU	China	Thank you for your comment. High resolution figures are added in the final version
53753					While minor copy editing was performed on the ~3,100 comments, in the interest of full transparency, no effort was made to reconcile different perspectives within the comments. They were evaluated for technical merit for WGIII authors to consider during final draft preparations.	Government of United States of America	United States of America	Noted, Thanks
53755					As the authors revise the report and SPM, suggest focusing on readability of the text by, e.g., reducing the number and complexity of graphics to ensure the accessibility of the information presented. Many chapters are extremely long and would be served by streamlining the content to only the information that is relevant to the discussion on mitigation of climate change. For example, the lengthy presentation of the history of UNFCCC negotiations in Chapter 14 does not have bearing on any major conclusions and should be removed.	Government of United States of America	United States of America	Noted

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53757					SPM findings are often not fully supported by bracketed line-of-sight chapter citations, thereby lacking traceability to the underlying report and literature. This issue is continued in the underlying chapters, where text in Executive Summary paragraphs are not directly derived from the main chapter text (or lack the necessary citations for this trace-back). For example, information presented on 1.5 and 2°C pathways suffers from a lack of supporting references, often focusing on reporting the findings of a single source. Similarly, when discussing adaptation, the text is unclear where findings are drawn from the draft WGII volume and what are novel findings from WGIII.	Government of United States of America	United States of America	Thank you for the comment. These are carefully checked and revised/ corrected
53759					Authors will need to carefully review the underlying report to avoid language that implies the IPCC is making policy recommendations. In numerous chapters, theoretical discussions and philosophical statements overpower the rigorous assessment of whether current and potential mitigation options are demonstrated to be socially, economically, and politically feasible and proven to be effective at achieving environmental aims. In many of these instances, there is no robust discussion of alternative or competing theories, concepts, or philosophies, or of barriers to implementation. For example, there are many statements in chapter executive summaries and the SPM that state a policy option or pathway "can" or "could" achieve a desired policy outcome. In theory, such statements may be true, but the text does not adequately provide empirical evidence to support whether the finding holds true in the real world nor does it recognize the challenges involved in applying the concept or in realizing the implied results. This is of particular concern in Chapters 15 and 16. Such statements should be either deleted or revised to make clear the qualifications or conditions to the realism of the statement. In other areas, the report pre-judges policy outcomes that have not yet occurred and/or misrepresents policies of other bodies (e.g., related to technology neutrality; stranded assets under net zero energy systems; sufficiency; the Convention on Long-Range Transboundary Air Pollution; and the Human Rights Council). Also, in several cases, the report is overly prescriptive in asserting how certain assessments or accounting exercises should be conducted (e.g., improved forest management or bioenergy impacts assessments in Chapter 7).	Government of United States of America	United States of America	Noted
53761					Behavior and lifestyle changes for demand-side mitigation can be highly sensitive for social, cultural, and individual meaning and identity. It is critical to present these ideas as neutrally as possible to prevent any misinterpretation that the IPCC is passing moral judgement on any practices or groups. In most cases, the authors navigate these challenges well, but given the sensitivity, it is important to review the final draft with this lens in mind. For example, when discussing consumption, authors should be careful when applying terms such as "wasteful", "excessive", or "responsible" as these imply judgment.	Government of United States of America	United States of America	Thanks and noted. Changed in many places the terminologies used apporpriately.
53763					Several reviewers highlighted areas where the draft report risks biasing the reader by using hortatory language or by omitting information regarding key aspects of a topic. For example, where relevant, the authors should provide more information on: the role of carbon capture and storage technologies in carbon dioxide removal technologies; the impact of future population growth on emission scenarios; the potential role for nuclear power; the need for more Research, Development, Demonstration and Deployment; disposal and transport of hazardous waste arising from expanded battery use in the transportation sector; the role of material efficiency, not only energy efficiency; and AFOLU in the discussion of near- and mid-term pathways in Chapter 4.	Government of United States of America	United States of America	Thank you. Some of these issues are being taken care of.
53765					There are numerous terms that, when used for the first time in a chapter, are not defined clearly in the text or in a footnote. Terms that include or imply subjective measures or matters outside the typical scope of the IPCC's mandate require specific attention to prevent misinterpretation by a diverse readership. Terms that are fundamental to the report themes (e.g., "transition" and "just transition"), terms that could be measured in multiple ways (e.g., "cost-effective" or "optimal" outcomes), and terms that have a variety of meanings to different audiences (e.g., "collective action" or "global governance") should be used only with care and be presented with a text-specific definition that is based on the author's assessment of relevant literature and based on robust evidence (including nuance for any definitions that may not be authoritative or agreed).	Government of United States of America	United States of America	Noted. Efforts have been made to clarify such terms where relevant
53767					The lack of definitions in chapter text may reflect a reliance on the WGIII Glossary. However, numerous terms in the Glossary include definitions of terms for which there may not be a generally understood meaning, and/or include an interpretive discussion that exceeds the purpose and scope of a glossary definition. If these interpretations are supported by research and properly cited, they should appear in the first usage in any chapter using the terms, with defining text in the main body or footnotes. The report should note if such terms do not have generally understood meanings, and clarify that the definition is only for the purpose of this assessment. These changes would provide greater clarity to the readers when they encounter such words in the body of the report, and would avoid providing subjective statements in the Glossary that are not supported by the chapters. Examples of terms for which such changes should be made include, but are not limited to: Blue Carbon, Energy Security, Climate Justice, and Just Transitions.	Government of United States of America	United States of America	Thank you for this useful comment. Definitions have been harmonised across the report to ensure consistent definitions are used in the relevant chapters. Many chapters also include introductory sections on key concepts and discussion on terminology where different definitions exist in the underlying literature. These provide an overview of the definitions, with references provided, and clarify how the terms are used in the chapter's assessment.
53769					Transition – The concept of "transition" is a major theme throughout the report, yet greater coherence in the use of this term is needed across chapters. Each chapter should provide sufficient explanation of what is meant by "transition", so that each chapter can be read on its own. Moreover, the report should provide an analytical basis for the end points of a transition, not an assumed normative or political one. In some chapters, "transition" appears to refer to modeled or conceptual scenarios of changes in technology or energy systems over time; in other places, it refers to socio-economic processes; in both cases, the discussion often appears theoretical. A definition could build upon the Social Science Primer supplementary material in Chapter 5 on the transition, the role of civil society, and policy options in Chapters 1 and 5. The cross-chapter box in Chapter 13 is also helpful, but should provide content beyond the names of national "Just Transition" policies, including the degree to which programs have been implemented.	Government of United States of America	United States of America	Noted. Efforts have been made to harmonise the concept across chapters.

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53771					Modeling and Scenarios - The report and its SPM should highlight the importance of using the full range of scientific literature, including, but not limited to, modeling tools that inform the scientific body of knowledge, particularly related to climate mitigation. Clearly IAMs have a role to play, but any given modeling tool has strengths and limitations. It is widely recognized that the IAMs, while of high value to the IPCC assessments, have limitations and effectively using their output requires understanding these limitations. IPCC authors should recognize and communicate the limitations of information drawn from IAMs and other models, especially in the context of assessing financial needs or costs or the feasibility of deploying emission reduction technologies at scale. Applying a range of model tools, including ones with geographic and sectoral disaggregation can strengthen the rigor of the findings. Several chapters assess other types of analysis, but this information is not sufficiently brought forward to the SPM. Additionally, recommend including a brief summary of the strengths and limitations of different models in the SPM and Technical Summary, including how these models are being applied in this report.	Government of United States of America	United States of America	Noted. Thank you for your comment. Throughout the SPM and the report there is detailed discussion of top-down models (i.e. IAMs) based findings and bottom-up (i.e. sectoral models) based findings.
53773					Comparison of 1.5 and 2°C Pathways – Figure SPM.6 compares emission pathways consistent with limiting warming to 2°C against pathways consistent with limiting warming to 1.5°C. However, upon inspection, this comparison is not as straightforward as it initially seems. The 2°C pathways presented in the figure have a 66% chance of achieving the target while the 1.5°C pathways have only a 50% chance of success. In addition, the 1.5°C pathways overshoot 1.5°C by 0.1°C midcentury. The information about likelihood of these pathways is contained in parenthetical remarks several bullets below the graphic and, at a minimum, should be presented more prominently within the figure itself. While authors may have chosen this approach with the intention of comparing the Paris Agreement aim to hold the increase in the global average temperature to to well below 2°C at a higher likelihood level than the aim to "pursue efforts" to limit the temperature increase to 1.5°C, this difference is not presented adequately in showing similarly formatted lines within the figure. Ideally, authors would also present information on 1.5°C pathways with a 66% chance of success in this figure and throughout the underlying report.	Government of United States of America	United States of America	Noted. Chapter 3 has been completely revised and most of the issues raised here are now also being addressed.
53775					Social Cost and Price of Carbon - Pursuant to "Executive Order 13990 Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis" and the "Memorandum on Restoring Trust in Government Through Scientific Integrity and Evidence-Based Policymaking", the United States has begun a process to make sure that the estimates of climate damages used in Federal agency benefit cost analysis reflects the best available science and economics. "Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990" presents interim values for the social cost of greenhouse gases, and contains useful information on developments related to damage functions and discounting. The WGIII assessment would benefit from the information contained in these sources. Where carbon pricing is highlighted as a centerpiece of mitigation pathways, the report should also address why existing carbon prices are far lower (or freely allocated credits more numerous) than those consistent with limiting temperature rise to 1.5 or 2°C, and the drivers of this phenomenon, including concerns of competitiveness, political dynamics of cost bearing, trade exposure, and so on.	Government of United States of America	United States of America	Noted. Chapter 3 has been completely revised and most of the issues raised here are now also being addressed.
53777					Equity - The focus of equity is primarily based on addressing social factors (e.g., marginalized groups, the poor and vulnerable), but the report should also include information on impacts to workers in exposed sectors (e.g., energy, agriculture). For example, while the report assesses fossil fuel producers' stranded assets, it does not assess the "stranded livelihoods" of those who depend on the industry. Another important dimension of equity in transitions is access to new technologies and systems. Without targeted policies, many less skilled people could be left behind, resulting in increasing inequity. While this issue is handled fairly well in the context of energy poverty, small businesses and noncorporate farmers and ranchers should be considered as well. This is particularly relevant to the discussion of national and subnational policies because policy ambition is often bounded by the political drivers related to such groups.	Government of United States of America	United States of America	Noted. Efforts have been made to harmonise the concept across chapters. Equity is a thread that runs throughout the report.
53779					Finance - In Chapter 15, there are a large number of unsupported statements, including references to missing sections, a pervasive anti-market bias, and an excessive focus on short-term pandemic recovery stimulus and quantitative easing. In addition, there is little coverage of major sources of public and private investment and finance and few real-world examples of how finance can enable effective climate mitigation actions. An overemphasis on international public finance over private finance, as well as renewable energy financing over nature-based mitigation financing, leads to potential bias and prescription. Verbose and unnecessary tangential discussions of renewable energy should not be included in a finance focused chapter. Related to prescription, the text offers specific policy options and judgments on what is equitable, which does not adhere to IPCC's policy neutrality position. Finally the inherent limitations of using IAMs for costs and investment needs should be discussed in more detail.	Government of United States of America	United States of America	Thank you for your comment. The chapter has been revisited to ensure references are provided throughout all sections. Efforts have also been made to strengthen sections on enabling environments, including private sector financing.
53781					International Agreements – The report includes several inappropriate characterizations or interpretations of international agreements and instruments, including the UNFCCC and Paris Agreement. It is important that international agreements and instruments are described accurately and without embellishment. IPCC reports should refrain from paraphrasing, interpreting, or opining on negotiations or political dynamics underlying the UNFCCC or Paris Agreement. It is not the IPCC's role to offer legal interpretations of provisions in international instruments as this is outside the scientific assessment scope of the IPCC, but rather is addressed between and among states under the UNFCCC or other appropriate fora.	Government of United States of America	United States of America	Accepted. References to international agreements have been revisited across the chapters to ensure it accurately reflects agreed language.
53783					Agriculture, Forestry, and Other Land Use (AFOLU) – AFOLU needs to be treated more thoroughly and also more consistently across the report and within the SPM. A number of chapters devote insufficient attention to AFOLU (e.g., Chapters 4, 5, 9, 15), particularly relative to the much greater attention devoted to energy. In addition, the report presents an unbalanced and at times conflicting representation of AFOLU. Some chapters point toward AFOLU-based mitigation as compensating for delayed/slow mitigation in other sectors, while other chapters caution against placing too much confidence in emission offsets from AFOLU. Even within the SPM, these conflicting perspectives come through strongly (e.g., Sections C3 and C9). The strong statements suggesting biomass-based CDR is a tried-and-true approach (and critical for achieving Paris Agreement temperature goals) need to be revised to capture the concerns raised elsewhere in the report.	Government of United States of America	United States of America	Noted - the report includes a substantive discussion on this topic in chapters 7 and12

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55115					Replace the phrase "nature-based solutions" with "ecosystem-based approaches". The phrase “nature-based solutions” (NBS) was proposed in 2009 by the International Union for the Conservation of Nature (IUCN) to designate a broad category of actions employing natural elements to produce desired environmental effects. The expression doesn’t designate pre-existing natural phenomena that lend themselves to descriptive definitions, such as chemical elements or biological species, but rather a set of human actions that can only be represented by a stipulative definition. To be effective, a stipulative definition of a policy tool such as NBS must have two properties: precision and legitimacy. The purported concept of “nature-based solutions” lacks both. First, there is no consensus about the nature and scope of such actions. For instance, some stakeholders advocate a broad approach whereby NBS designates any intervention employing living organisms to produce desired environmental outcomes, such as industrial forestry with improved tree varieties for carbon sequestration. Others defend a stricter approach whereby such interventions can only be called NBS if additional criteria are met, such as the use of a diversified set of native species instead of monocultures of engineered or exotic plant varieties. Second, the notion of “nature-based solutions” lacks legitimacy because its definition was never debated and agreed within the framework of a universal or nearly universal intergovernmental institution. Instead, repeated attempts have been made to impose this expression by technocratic fiat without the appropriate discussion in truly representative fora. In view of the above, Brazil requests that all references to “nature-based solutions” be replaced by the expression “ecosystem-based approaches” (EBA). The concept of EBA covers roughly the same semantic field as NBS, but doesn’t have the aforementioned problems. As for precision, the meaning of EBA is extensively spelled out in Decision VII/11 of the Convention on Biological Diversity (CBD). The concept of EBA also has the requisite legitimacy since its definition is the result of extensive and inclusive discussions within the CBD, the most representative forum in this field, with the participation of almost all UN member states, and the active engagement of all key stakeholders from academia and civil society.It is evident that there is no clarity on what NBS actually encompasses or what it actually brings to the table, different of what already exists, and it has been used according to individual interpretations of what one might think it means. So much so, that it is not consistently used in all the chapters of the AR6, where some authors prefer to work under other epistemological assumptions. Being a volatile and undefined concept, it clearly cannot be considered as a key concept and a universal prescription, as some authors are trying to promote.	Government of Brazil	Brazil	Noted. The report recognises that NBS is unclear and in many cases alternatives are used, however NBS remains a term used in the underlying literature, and this is also reflected in the WG III assessment
60379					Remarks on the glossary on the definition of CCU: The definition of the term CCU is not appropriate and is incoherent with the use of CCU and CCUS in the report. In the current version of the report, the term CCUS (Carbon Capture Utilisation and Storage) is still used at some places but not clearly defined and in most cases, this term discusses only Carbon Capture and Storage (CCS) technologies and not the utilisation phase. CSS and Carbon Capture and Use (CCU) distinctly differ regarding their CO2 reduction potential, the underlying technical processes and outcomes, their effects on climate mitigation, their business models and their environmental policy targets. Therefore, presenting commingling CCS and CCU does not do justice to the specific characteristics of the two concepts and could be counterproductive for the further development particularly of CCU. Therefore the term CCUS should be separated in CCS and CCU and both options should be clearly addressed independently (Cuéllar-Franca and Azapagic, 2015, Bruhn et al., 2016, Arning et al., 2019). Please note that the definition formerly given of CCUS in the glossary (If the CO2 is stored in a product for a climate-relevant time horizon, this is referred to as CO2 capture, utilisation and storage (CCUS)) is not correct and is incoherent with the use of the term CCUS in the report as in most cases CCUS is used in the context of Carbon Capture and (geological) Storage. The high level report of the Science Advice for Policy by European Academies (SAPEA) has explicitily said: “ measures, regulations and incentives should examine CCU in a holistic, integrated, coordinated and transparent manner » (SAPEA, 2018). Based on the references below, I propose the following definition of CCU: “Carbon Capture and Utilisation (CCU) is a broad term that covers all established processes that aim at capturing CO2 – either from industrial point sources, converted biomass or directly from the air – and at converting this captured CO2 into a variety of products such as e-fuels, chemicals and materials. CCU technologies can: •Reduce net CO2 emissions, help reaching zero emission targets and creating negative emissions when CO2 is captured directly from the air or biomass conversion and stored permanently into building material via mineralization processes •Replace fossil resources and thus support a transformation towards renewables in the energy, transport, chemical and material sectors •Stimulate the energy transition by enabling energy storage through power-to-X approaches •Contribute to develop a circular economy by converting waste emissions into resources (Wich et al., 2020) Other terms such as CO2 transformation, CO2 conversion, CO2 recycling, CO2 valorization, or CO2 upcycling can also be used.” References: e.g. •Styring et al., 2011, Carbon Capture and Utilization in the Green Economy. Centre for Low Carbon Futures, York.,•Ampelli et al., 2015, Phil.Trans.R.Soc.A, 373., •GCI, 2016: Global Roadmap Study of CO2U Technologies, LUX Research & Global CO2 Initiative., ,•Bushuyev et al., 2018, Joule, 2(5), pp.825-832. •SAPEA, 2018, Science Advice for Policy by EU Academies, Novel Carbon Capture and Utilisation Technologies-Research and Climate Aspects, Evidence Review Report, 2. •Hepburn et al., 2019, Nature, 575, 87-97. Breyer et al., 2019, •Kätelhön et al., 2019, PNAS, 116, 23, 11187-11194. •CCES, 2019: Carbon Utilization – A vital and effective pathway for decarbonization, Center for Climate and Energy Solutions.. •Arning et al. 2019, Energy Policy, 125, 235–249.•Bruhn et al., 2016, Environmental Science & Policy, 60, 38–43. •Cuéllar-Franca and Azapagic, 2015, J.CO2.Utili., 9, 82-102.•Wich et al. 2020, Frontiers Energy Research, 7, 162.	Célia Sapart	Belgium	Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.

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60499					The role of CO2-based fuels also called synthetic fuels, e-fuels or powerfuels is acknowledged in the IPCC AR6 WGIII SOD, but the related references and major statements do not reflect the state-of-the-art of the literature on this subject. In the current version, CO2-based fuels are not considered as drop-in solutions and their deployment is considered as unlikely in the near to mid-term. This statement does not reflect the technology advancements presented in the recent literature nor the readiness level of numerous CO2 to fuel projects all over the world. To give a concrete example, the first flight using e-kerosene has started flying early 2021 in the Netherlands (https://www.transportenvironment.org/news/first-passenger-flight-performed-using-clean-fuels-sort). CO2-based fuels can find a role in sectors that are harder to decarbonize, such as aviation, shipping and energy intensive industries since hydrocarbons have volumetric energy densities that are orders of magnitude above those of hydrogen and present-day batteries (e.g. Dimitriou et al., 2015, Schmidt et al., 2017, Hepburn et al., 2019, DENA-Powerfuels in Aviation, 2019). The long-term use of carbon based energy carriers in a net zero emissions economy relies upon their production with renewable energy, and upon low-cost, scalable, clean hydrogen production, e.g. via the electrolysis of water. The estimated potential for the scale of CO2 utilization in fuels varies widely, from 1 to 4.2 Gt CO2 yr−1, reflecting uncertainties in potential market penetration. The high end represents a future in which CO2-based fuels have sizeable market shares, due to cost reductions and policy drivers (Hepburn et al., 2019). In the near-term (2030), the CO2 used to produced alternative fuel will mainly come from point sources (e.g. Farfan et al.,2019), while in the mid-term (2040), it will come from direct air capture (DAC) (RAM et al., 2020, Breyer et al., 2019, Drechsler and Agar, 2021). Life-cycle analysis demonstrate that both point source and DAC to fuel pathways can provide climate benefit over conventional diesel fuel if a low carbon source of electricity is used (e.g.Daggash et al., 2018, CONCAWE, 2019, Liu et al., 2020,). The chances for these CO2-based fuels to succeed will strongly depend on their compatibility with existing technology and infrastructure, with the growth and price of renewable energy and with the development of appropriate policy and market incentives (Grim et al., 2020). Despite these challenges, most of the boundary conditions (fuel composition, price, feedstock) for near- and medium-term deployment of CO2-based fuels are clear; now, it is a matter of finding the most economical route towards the synthesis of these fuels (Ramirez et al., 2020). In term of technologies, recent advances in the CCU field offer untapped potential for the realization of CO2 conversion to fuels. Today, a large palet of technologies exist, some are close to commercialization, others are at the benchtop/pilot scale, and some have yet to be scientifically proven. Thermochemical and bioelectrochemical routes offer the most technically feasible near-term opportunities for CO2-based fuels, representing immediately deployable pathways to high-value and relatively high-volume products. These pathways are the closest to commercialization and are ready to be upscaled in near-term (5-10 years) while other routes such as the direct electrochemical pathways are promising on the long-term but will take several decades to overcome the current technical barriers (Diaz et al., 2018, Messias et al. 2019, Edwards et al., 2019, Bushuyev et al., 2020, Masel et al., 2021). Close to 50 high Technology Readiness Level (TRL) projects on CO2 to fuel exist in Europe and many of them will reach commercialisation in the near-term (before 2030). Please find a few examples below with the forecasted production of CO2-based fuel in near-term (within 5 years): -Norsk-efuel (DAC to jet-fuel)=> 100 Million ton of jet-fuel/year -Carbon Recycling International => 4000 tons of methanol/year -Jupiter 1000 (CO2 flue gas to CH4) : 25Nm3/h of methane	Célia Sapart	Belgium	Noted.

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60505					The role of CO2 mineralisation as climate mitigation option and enhancer of circular processes for the industry should be cited in Chapter 11.]. Carbon mineralization is an emerging approach to remove CO2 from the air and/or store it under the form of carbonate minerals into building materials. Originally, mineralization is a natural process occuring on geological time-scale during the weathering of silicate materials and rocks rich in Ca and Mg, coming from the Earth's upper mantle. Because it utilises this naturally available chemical energy, this method may offer a low cost means to mitigate greenhouse gas emissions and lock CO2 into solid carbonate minerals, in a permanent and nontoxic way (e.g.Zevenhoven and Fagerlund, 2010, Giannoulakis et al., 2014, Cuéllar-Franca et Azapagic, 2015, Kaliyavaradhan et al., 2017, NAS, 2019, Huang et al., 2019, Lee et al., 2020, Pan et al., 2020). The conversion of CO2 into carbonates may offer a potential to convert low value materials into useful products, namely concrete, asphalt and construction fill." (SAM, 2018)A promising pathway is to let CO2 react with mineral- rich industrial wastes (e.g. concrete debris) to create new building material.This circular concept allows to decrease CO2 emissions and landfills, but also to sequested CO2 permanently in valuable products (e.g. Khoo et al., 2011, Xuan et al., 2016, Ebrahimi et al., 2017, Pasquier et al., 2018, Zhang et al., 2020, Tripathi et al., 2020). Moreover, mineralisation of CO2 into cementitious materials improves upon material quality by densifying and reducing water absorption of such materials whilst permanently imprisoning CO2 (Tam et al., 2020) Ostovari et al., 2020 have shown that all considered CCU technologies for mineralization could reduce climate impacts over the entire life cycle based on the current state-of-the-art and today's energy mix. Reductions range from 0.44 to 1.17 ton CO2e per ton CO2 stored. For all mineralisation pathways evaluated, the carbon footprint is mainly reduced due to the permanent storage of CO2 and the credit for substituting conventional products. Thus, developing suitable products is critical to realize the potential benefits in practice. Then, carbon capture and utilization by mineralization could provide a promising route for climate change mitigation. Current data suggests that up to 1 Gt per year of the cement market could be substituted by mineralization products. Di Maria et al., 2020 conducted an LCA of carbonated steel slag including CO2 capture and confirm that mineralization is a negative-carbon-footprint technology, since the amount of CO2 taken up and stored during the process is higher than the amount of CO2 emitted, considering the whole life cycle. While comparing the findings to Portland cement concrete blocks, they report GHG emission reductions of up to 77%. At endpoint, they report that concerning the damages to human health and ecosystems, the carbonated blocks have a lower impact compared to the traditional PC-based concrete, and an overall positive environmental impact. The manufacture of carbonated aggregates starts to be commercially established at global scale, and recent advances in technology include a mobile plant that directly utilizes flue-gas derived CO2 in the mineralisation process in the UK (Hills et al., 2020). At mid-term, direct air capture combined with CO2 mineralisation could allow creating negative emissions as CO2 will be removed from the atmosphere and store permanently in materials (e.g. SAPEA, 2018, Beuttler et al., 2019, Breyer et al., 2019). ((e.g. SAPEA, 2018, Beuttler et al., 2019, Breyer et al., 2019).•Giannoulakis et al., 2014, International Journal of GHG Control, 21, 140-157.•Beuttler et al., 2019, Frontiers n Climate, 1 :10.•Breyer et al., 2019, Joule, 3, 2053-2057.•Di Maria et al, 2020, International Journal of Greenhouse Gas Control, 93.•Ebrahimi et al., 2017, J. of Cleaner Production, 156, 660-669.•Cuéllar-Franca and Azapagic, 2015, J.CO2.Utili., 9, 82-102.•Huang et al., 2019, J. of Cleaner Production, 241, 118359.•Lee et al., 2020, J. CO2. Util., 37, 113-121.•NAS, 2019, Negative Emissions Technologies and Reliable Sequestration, The National	Célia Sapart	Belgium	Noted.

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60509					Carbon Capture and Utilisation (CCU) is now considered as a solution to mitigate climate change in the IPCC AR6 WGIII SOD, however its definition and several key messages need to be refined to reflect the literature. CCUS is barely used anymore, but CCU and CCS are still mixed sometimes, especially when discussing the barriers and needs of CCS, which does not do good to CCU as the barriers and needs are not the same. CCU technologies are available now and offer solutions to reduce net CO2 emissions with an estimated potential impact of gigatons equivalent CO2 emissions. Indeed, CCU technologies have the potential to utilize up to 8 Gt of CO2 per year by 2050 (GCI, 2016, Hepburn et al., 2019), this is equivalent to approximately 15% of current global CO2 emissions. Moreover, When CO2 is captured directly and stored permanently via mineralization into building materials, CCU can also create negative emissions (e.g.Di Maria et al., 2020, Ostovari et al., 2020). Unlike other options, CCU technologies provide drop-in solutions which can be implemented without requiring significant modification of existing production, distribution and use infrastructure (e.g. Ampelli et al., 2015, Hepburn et al., 2019). Another important asset of CCU technologies is the utilisation of CO2 as carbon feedstock to replace fossil resources (e.g. Sternberg et al., 2017, Daggash et al., 2018, Kätelhön, et al., 2019, Thonemann, 2019) and support the development of a circular economy, e.g. when CO2 is used together with industrial wastes to create materials (e.g. Di Maria et al., 2020, Ostavari et al., 2020). CCU technologies have the potential to provide solutions to hard-to-abate sectors, but also to generate revenues through producing marketable products (e.g. Hepburn et al., 2019, Zhu, 2019). Because of their lack of granularity, Integrated Assessment Models (IAM's) have yet failed in simulating the complexity of the different CCU options to realize net zero or negative CO2 emissions (e.g. Detz and Zwaan, 2019). Consequently, no exhaustive quantification exists today on the climate mitigation potential of this large panel of technologies. However, their key role should be considered as one building block in a portfolio of mitigation measures (e.g. Wilson et al., 2016, GCI, 2016, Grüber et al., 2018, IEAGHG, 2019b, Detz and Zwaan, 2019). Following the CCU concept, CO2 can be captured at point sources or directly from the atmosphere and subsequently converted into valuable products such as building materials, chemicals, synthetic fuels (e.g. Styring et al., 2011; von der Assen et al., 2013, SAPEA, 2018, Kätelhön et al., 2019). The duration of the CO2 storage into a product strongly varies from days to millenia according to the applications. However, in term of environmental assessment, CCU technologies should not be assessed only with respect to the amounts of CO2 that can be used nor to its storage duration, but rather it is essential to determine the life cycle of the CO2-based product generated (e.g. Bruhn et al., 2016, Zimmerman et al., 2018, Nocito and DiBenedetto al., 2020). If these products are assumed to be substitutes for fossil-based products and thus provide the same service (i.e. it would be used and disposed of according to the same patterns as conventional products), the focus of the life-cycle-analysis may lie in the cradle-to-gate phase (e.g. Kätelhön, et al., 2019). Two important points should however be highlighted (Arning et al., 2019, IEAGHG, 2019b, Zhu, 2019): 1)If CO2-based products can be produced with less environmental impact (including GHG emissions) than fossil-based ones, an environmental benefit can be asserted, independent of the storage time of CO2 in the products. 2)If CO2-based products are recycled i.e. if their end of life CO2 emissions are captured to generate new products, the duration of CO2 storage in a product is not anymore crucial to consider in the life cycle analysis.	Célia Sapart	Belgium	Noted. In Chapter 6, CCS is use to capture the idea of storing carbon for long periods of time. Many forms of CCU do not actually store carbon for meaningful amounts of time, and many do. So it is not viable to discuss CCUS as a solution without raising concerns that this includes forms of CCU that will not store carbon.
60811					(MG1) [Overall] This is a rich report, but the Technical Summary in particular and some chapters show signs of being thrown together in some hurry. The TS could in principle be a vehicle for helping valuable cross-chapter intellectual integration, and summarizing the core and cross-cutting intellectual content, but clearly has not yet done so. The Co-Chairs/TSU could consider whether and how to convene discussion across the Tech Summary to address some obvious inconsistencies, narrative (as already suggested by Ambuj), and as a process to increase coherence, in ways that could feed back into relevant chapters.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60813					(MG2) The report does not yet clearly communicate a core theme or narrative with which to help move forward global and integrated thinking on mitigation. There is a striking separation between technical/data/numeric analysis, and policy/social analysis. It is 30 years since the first IPCC report and UNFCCC, and policies (overview Chap.13) began to accumulate from around 2000 - have all these efforts has no effect on emissions? What about "policy attribution" analysis? See also my final Whole REport remark (MG32). To the reader it is almost as if we taking the past as exogenous, and then projecting a radically different future in which policies are suddenly adopted and have impact (though in fact, Ch.3 models refer to 'current policies' we dont hear anything about their impact to date)? Also at present in places the report seems to straddle – or be intellectually confused by - a transition of thinking, and hence has some incoherence. Following remarks try to explain and illustrate this.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60815					(MG 3) The report repeats and reinforces the urgency of action. Expectations about how global mitigation can be delivered affect - mostly, implicitly - the focus and metrics reported in AR6. The report could be better shaped if the authors debate more deeply the processes through which 'Strengthening the Response' (the final SPM section) could actually occur, and be monitored and evaluated, as follows.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60817					(MG 4) My cross-cutting comments below raise issues in (A) consistent & relevant treatment of global data, trends and scenarios (B) implications of the main 'multi-level/bottom up' social science perspective, including for case studies; and more briefly (C) cross-chapter evidence on impact of past multilateral efforts, and (D) coherence of assessment frameworks.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60819					(MG 5) A. Global data, trends and scenarios. Our report will be published in 2022 and using data only to 2018 already makes it look dated. Far more recent data are available (and already in Ch.2) for at least for what we note as the biggest driver of climate change, FFI CO2. Because of complexities around GWPs we already say we strive to present data separately for different gases to the extent possible. We should use 2019 to extent possible	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60821					(MG 6) We have a dilemma in how to communicate the '2020' base year of scenario projections – the government consultations already showed this to be confusing, having to explain it is not actual 2020 emissions. Since 2019 emissions at least for FFI CO2 were very close to 2018 (Ch.2) I suggest that AR6 should update to 2019 data in general, and that the description of base years in the global projection scenarios could be written as 2019(20) to avoid confusion between real and assumed – we explain that because of the Covid anomaly, and given that global emissions were roughly flat between 2018 and 2019, we take that 2018-2019 level as the simplest representation of 'counterfactual' 2020 emissions in the absence of Covid	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.

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60823					(MG 7) Data on changing trends since AR5 are generally presented as aggregate, 2010-2018 compared to the previous decade. Whilst these are big systems, an almost decadal average really is too long. It would be far more insightful to consistently report for 2010-2014, and 2015-19. From a brief look at the EDGAR data, it seems that global CO2 growth rates fell from over 2%/yr in 2010-2014 to just over 1%/yr in 2015-19. That is same as population growth, so it appears that in the five years 2015-19, global per-capita CO2 almost stabilized. I think such stats are worth noting as part of a more consistent assessment on whether the world may be approaching peak emissions (at least, per capita).	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60825					(MG 8) If global per-capita emissions have roughly stabilized this seems important to say and offers a basis to focus on initiating and accelerating decline – which is a far more credible message than saying emissions are still rising and the whole world has to make an abrupt and sudden change to steep descent (see next comment). All the social science indicates this to be impossible – but accelerating a trend that is already almost flattening, into an accelerating descent, is not.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60827					(MG 9) Inconsistencies across Chapters 1-4 must be addressed, in terms of carbon budgets, trajectories and net zero dates. Chapter 2 has great detail on trends to date, some good material on lock-in albeit with mixed language on 'committed' emissions (their language in TS seems better and avoids the conundrum of stating that future emissions need to be much lower than already committed..), and states clearly that we exhaust 1.5C carbon budgets by 2030 at present emission levels. Chapter 3 then presents 'net zero' dates in range 2055-80 – this appears to be because optimizing models now result in immediate and steep emission reductions, a 'convex' pattern which 'buys time' for a long tail of hard to treat emissions. But Chapter 4 then underlines the emission and implementation gaps, sets emissions in socio-economic context, and national net-zero strategies, with a totally different picture; Figure 4.2 shows that NONE of the 18 countries illustrated project emission reductions steeper than linear.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60829					(MG 10) One way to frame and explain these differences more coherently could be with reference to the Four Analytic Frameworks in Chapter 1, which emphasizes the need to consider all four for any coherent integrated view of mitigation. Chapter 2 is strong on general emission trends – pathways – together with technology, innovation and transitions. Chapter 3 models are based on aggregate global optimization with perfect foresight, with little reference to the other frameworks or explicit indication of what determines rates of growth and decline. Chapter 4 is grounded in the complex realities of national policies including ethics & equity, and politics – a reality check which makes it plain that the world cannot conceivably achieve the radical, immediate reductions of the Ch.3 global optimizing models.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60831					(MG 11) What then is the relevance of the net zero dates emerging from Ch.3 models? In terms of pathways, the Chapter 4 (X-chapter box 3) - SPM.6 – which shows various linear to 2030 – seems both much clear and more plausible as a basis for discussion, even if the 1.5C trend still seems far beyond anything emerging from the national data. Also note: variation between GHG (SPM.6) and CO2 (SPM.7) is really confusing – the former never reaching close to zero by 2050, but presumably would if in terms of CO2.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60833					(MG 12) Overall, a more consistent approach to recognizing emitting systems as path dependent – implicit in the attention to stranded assets, lock-in, and induced innovation – could help to focus on issues of trends and relevant dynamics and metrics of change.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60835					(MG 13) B. The social science assessment suggest we are now in a world of disaggregated, quasi-voluntary approach to implementation, particularly in the context of the Paris Agreement, since the PA is only legally binding in terms of process, with no legally binding commitments or compliance. Delivering the global goals can only come as a disaggregated and evolutionary process, with a complex and diverse set of motivations, actors and institutions.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60837					(MG 14) This would imply a significant focus on positive examples and their potential for growth - leading cases of technologies, national emission reductions, etc, to identify positive potentials, and lessons, which could be attractive examples that others could adapt and magnify, together with the dynamics, mechanisms and pace through which they could grow.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60839					(MG 15) However the "hard" statistics and other aspects of the AR6 narrative focus more on global statistics. Obviously it is simpler to report global, but nevertheless serious thought needs to be given to this dilemma. I offer four main examples.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60841					(MG 16) Ex. 1: glass half full or half empty? The report captures much better than the FOD the remarkable progress in clean technology costs. It seems much more tentative regarding their deployment rates and implications thereof (linear trend – totally inadequate : exponential extrapolation – potentially transformative, clearly for energy sector by 2030, and land transport, with c. 15 years). In SPM there is one strong paragraph on the countries that have sustained emission reductions, but these examples receive little attention in the rest of the report, narrative or case studies. The main framing for data seems still based on the well-worn mantra – increasingly, 'doom and gloom' - of inadequate global progress and ever growing global risks.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60843					(MG 17) Ex. 2: Differentiation (a). The SPM, and Tech Sum somewhat, downplay distributional data beyond the highest level of regional aggregation. For example, in touching briefly on the first level (5-region groupings), one only sees from SPM that developed countries emit average 13.1 tCO2e/cap. Nothing indicates that this comprises North America & Australia at around 20tCOe/cap, and rest of OECD averaging below 10, with some down close to 5. Even the TS doesn't explicitly flag this, or the huge difference eg. between East Asia and South Asia in per-capita emissions. See my specific suggestion re SPM on this.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60845					(MG 18) Ex. 2: Differentiation (b) The AR6 could – and needs – to better illuminate the sheer diversity of regional experiences and trends. The assessment that decarbonizing industry and agriculture is harder than energy and transport, and that "per capita material stocks in several developed countries have saturated", clearly implies that one would expect the global transition to include a stage at which many developed countries become lower GHG per-capita emitters than many developing countries (even aside from the UNFCCC principle of developed country leadership). AR6 gives little evidence to assess this. The TS statement that "Developing countries have lower per-capita emissions" is clearly true in aggregate but not in specifics – there are numerous counter-examples.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60847					(MG 19) Ex. 3: Co-benefits (a). Much of the SPM (and our Chapter 1) suggests quite a neutral stance on co-benefits, beyond a narrative on need to 'minimize tradeoffs and maximize synergies' particularly with SD / SDGs. The Tech Summary seems to indicate a much evidence base: Almost every sectoral chapter identifies significant positive co-benefits to mitigation which seem to outweigh the negatives. Chapter 17 (/final section of Tech Summary) does a powerful job of bringing these together.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.

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60849					(MG 20) Ex. 3: Co-benefits (b). Strengthening attention to co-benefits is not to negates the potential negatives (some very important). But aside from all the specifics, which already seem to point to a positive balance (previous comment), Chapter 1 (p.56, lines 37-40) points to a simple underlying logic (and clarifies terminology): we may strengthen this in final draft. On reflection the SPM (and Chapter 1) could robustly move beyond the present 'positives and negatives' tone – the natural default for academic balance - and more consistently align with the balance of evidence presented in the Tech Summary. Implicitly this seems the intention and logic behind the Fig.SPM.1 and SDPS narrative (Shifting Development Pathways towards Sustainability), but that relationship doesn't (yet) come out clearly.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60851					(MG 21) Ex. 4: Case studies (a). Viewed from the question of what case studies would be most important for assessing key examples of progress and lessons, the selection of "Case studies in sectoral chapters on integrated policymaking for sector transitions" (Table TS.9) seems bizarre. The criteria for selection (at least, for summary in TS) should be spelled out. If the world needs clear examples of major sectoral emission reductions or technological transformations at scale, obvious examples for energy-related emissions would include the German Energiewende; UK Electricity Market Reform (including offshore wind); CDM and China; electric transport stimulus in California, France and Norway and e-mobility in China; and the transition from incandescent lightbulbs to LEDs, including the Indian bulk purchase, for example. All these are well documented, and have had major impacts.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60853					(MG 22) Ex.4: Case studies (b). Instead the case studies presented in TS.9 appears as (i) a random mix which includes several which are just plans and not even implemented, (ii) mostly not at national scale, (iii) mainly focused on developing countries (why?) and (iv) are not assessed, the "findings" – the title of the table – do not include any evaluation of actual outcomes or effectiveness. A cynical reader might conclude this looks more like a set of efforts supported by foreign aid, directed at developing countries, which those involved want to advertise - rather than an attempt by IPCC authors to systematically select, highlight and evaluate lessons from implemented initiatives which have had a big impact on emissions or technology.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60855					(MG 23) C. As well as domestic policies and progress, AR6 is a key opportunity to assess the effectiveness of international climate agreements to date. By far the biggest is the Kyoto Protocol, which was NOT significantly assessed in AR5. This should include integration of evidence across Chapters 2 (correlation / causation with countries reducing emissions), 13 (the growth of climate legislation and instruments), 14 (formal appraisals of Kyoto's effectiveness), 15 (growth of international finance including CDM) and 16 (indices of innovation linked to Kyoto's adoption or entry into force). On this topic, at present there appear to be contradictory statements between Chapters 2 and 14, and neither covers the main technical literatures assessing Kyoto's impacts.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60857					(MG 24) Though there was 100% legal compliance with Kyoto commitments, this of course is not the same as impacts and lessons, which are varied and numerous (refs communicated to Chapters 2 and 14 detail emission impact assessments, which seem on average to attribute c. 7 % emission reductions across participating KP Annex B countries). A cross-chapter appraisal – maybe in Chapter 2 (emission impacts) and/or 14 (wider dimensions?) - should link evidence re effectiveness on various measures from the various chapters, alongside the wider lessons around Kyoto's scope and durability. Maybe a X-chapter / TS box ?	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60859					(MG 25) Such cross-chapter assessment of Kyoto might also help us understand the strengths and limitations of the 'global public good' framing with its broad assumption that goal-setting and specific commitments can be negotiated, and the conditions under which these may drive implementation through discrete climate policy. There is adequate literature, and the lack of consistent assessment of the lessons from Kyoto, with some chapters hardly mentioning what has been by far the biggest and most ambitious attempt to drive climate action through multilateral processes, seems a glaring omission in AR6.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60861					(MG 26) D. Transformation dynamics & assessment frameworks. Improved intellectual integration across the report could include the dimensions, metrics and frameworks used. Chapter 1 (section 3.6) indicates some common elements and interrelationships across the Feasibility, Enabling, and Policy Evaluation dimensions of assessment. Chapter 1 also underlines that there are four main ANALYTIC frameworks (ie. theories and methods of analysis, and associated objectives and metrics): aggregate efficiency; ethics & equity; transition and transformation, and psychology and political frameworks. The final draft of Chapter 1 will also illustrate how these in turn relate to the Dimensions of assessment.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60863					(MG 27) It might help readers – and generate additional insights - if different chapters show consistent awareness of the above dimensions and frameworks.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60865					(MG 28) Following the emphasis of SR1.5 on transformations, there seems a curious lack of analytic focus on this in AR6. There are some scattered indications in a couple of chapters. It forms one of the Four Frameworks summarized in Chapter 1. It maybe the least extensive literature probably because the world has never before had to grapple with a challenge of fundamental but purposive transformation on this scale before). But literature is significant nonetheless, the topic was hardly covered in AR5, and the theme is not well covered across the report. Is the material on this in Chapter 1 adequate, or could or should Chapter 16 be expanded to cover transition and transformation?	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60867					(MG 29) even aside from the wider transitions literature, AR6 does not adequately grasp the role of deployment-induced innovation and cost reductions associated with industrial & supply chain developments, and interdependence with infrastructures; interlinked examples span several sectoral chapters, and interact strongly with financial systems. In combination also these create considerable path dependence – for both bad (lock-in risks) and good (accelerated cost reduction and growth of clean energy industries & associated constituencies).	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60869					(MG 30) Somehow this evidence of the path-dependent, evolutionary nature of global socio-technical systems – and its obvious implications – just does not seem to come through consistently in AR6. It is weak in the SPM narrative (including the final section on innovation), and remains inadequately developed in the Tech Sum which could and should stitch together the evidence from the sectoral chapters better with these concluding cross-cutting chapters.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60871					(MG 31) There is a lot of repetition, both within chapters and across the report. To get a sense of the scale, the TSU could run a word frequency check - some terms probably appear thousands of times. Of course no-one is likely to read the report in entirety. But more cross-referencing instead of repetition could help?	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.

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60873					(MG 32) Overall, piecing together the evidence could – tentatively - suggest a broad narrative framing even at the global level. A closer look at global emission trends suggests that emissions growth slowed, and per-capita global emissions almost stabilized in the past five years (2015-19) along with the rapid development and expansion of low carbon technologies. Alongside declining population growth rates, from this point, a rapid broadening and deepening of policies has potential to accelerate absolute emission reductions globally, initially from the bigger emitters, and more broadly and globally shift development pathways towards sustainability (eg. Chs.4, 5, 17)	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60875					(MG 33) The SPM could bring together evidence on the extent to which policies (chs 13-16), albeit focused mainly on a limited number of countries, helped (a) to achieve this slowdown in emissions (mainly, Chs.2, 5 and 6?) and (b) secured the expansion and radical cost reductions secured in key low carbon technologies (Sectoral chapters, Ch.16) - which ideally could mention that key examples are summaried in the Tech Sum if globally-relevant, evaluated ones are included there.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60877					(MG34) Final observation on report structure - which cant be fixed but could be compensated for in the Technical Summary (see my final suggestion, MG35). Innovation is vital but it is unclear whether associated policies should be addressed in chapter 13 or 16, to an extent, both coverage and integration of innovation-related policies seem incomplete. This links to the paradox observed that whilst SR1.5 emphasised transition and transformation, there seems to be no focal point in AR6 for the associated literatures. These literatures emphasise intimate connections between behaviour, market policies & structures, technology-push, and wider socio-technological transition processes.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
60879					(MG35) These transition literatures ALSO point to the role of finance, and strategic expectations such as may be formulated through international agreements. One possibility to foster a more integrated analysis of transition therefore would be to recast section 6 of the Technical Summary so that instead of appearing as a set of disjointed chapter summaries, it is restructured to provide the analytic depth and connections across Chapters 13-16, and important aspects of Chapter 5, to support the final sections of the SPM in a far more coherent way.	Michael Grubb	United Kingdom (of Great Britain and Northern Ireland)	Noted.
61251					This review was conducted as a Group Review by the Science-Policy Interface of the United Nations Convention to Combat Desertification (UNCCD-SPI). All reviewers of IPCC WGIII AR6 Chapters are listed below (last name, first name) and has been communicated as such with the TSU according to the Guidelines for Group Reviews of IPCC Working Group II Reports	Graham von Maltitz	South Africa	Noted.
61253					von Maltitz, Graham Paul;	Graham von Maltitz	South Africa	Noted.
61255					Ravindranath, Nijavalli;	Graham von Maltitz	South Africa	Noted.
61257					Nairesiae, Everlyne;	Graham von Maltitz	South Africa	Noted.
61259					Lettington, Robert Lewis;	Graham von Maltitz	South Africa	Noted.
61261					King-Okumu, Caroline;	Graham von Maltitz	South Africa	Noted.
61263					Kapovic Solomun, Marijana;	Graham von Maltitz	South Africa	Noted.
61265					Ristic, Ratko;	Graham von Maltitz	South Africa	Noted.
61267					Luise, Anna;	Graham von Maltitz	South Africa	Noted.
61269					Oettlé, Noel;	Graham von Maltitz	South Africa	Noted.
61271					Vicente-Serrano, Sergio;	Graham von Maltitz	South Africa	Noted.
61273					Barger, Nichole;	Graham von Maltitz	South Africa	Noted.
61275					Deng, Xiangzheng	Graham von Maltitz	South Africa	Noted.

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Comment ID	From Page	From Line	To Page	To Line	Comment	Reviewer	Country	Chapter Team Response
61287					This comment refers to the Glossary A forthcoming report by the Integrated Drought Management Programme on INTEGRATED DROUGHT RISK MANAGEMENT A RAPID REVIEW OF RISK MITIGATION MEASURES (now in press) provides the following definitions in its glossary: Drought According to common usage and popular experience, droughts are disruptions to normal availability of water. Under the extenuating circumstances associated with droughts, agreed services for water supply may not be available as normal, unusual restrictions on certain uses of water and land may be imposed, and/or the costs to access water may increase. The French word for drought is : "secheresse", Spanish is: "sequía" and Arabic is "jafaaf". According to the most recent IPCC report (Shukla et al. 2019), the latest definition of drought is: "Drought A period of abnormally dry weather long enough to cause a serious hydrological imbalance. Drought is a relative term, therefore any discussion in terms of precipitation deficit must refer to the particular precipitation-related activity that is under discussion. For example, shortage of precipitation during the growing season impinges on crop production or ecosystem function in general (due to soil moisture drought, also termed agricultural drought), and during the runoff and percolation season primarily affects water supplies (hydrological drought). Storage changes in soil moisture and groundwater are also affected by increases in actual evapotranspiration in addition to reductions in precipitation. A period with an abnormal precipitation deficit is defined as a meteorological drought. Megadrought A very lengthy and pervasive drought, lasting much longer than normal, usually a decade or more." According to meteorologists, including WMO (1992), drought is more narrowly defined as a (1) Prolonged absence or marked deficiency of precipitation. (2) Period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a serious hydrological imbalance. Human-induced hydrological imbalances have been observed by some scientists (e.g. Van Loon et al. 2016) to increase population exposure and vulnerability to droughts. This anthropogenic water stress also is predicted by IPCC to accelerate faster than growing human demands for water due to ongoing climate changes (Shukla et al. 2019). For example, the IPCC Special Report on Global Warming of 1.5°C highlighted the attribution of an increase in droughts in the Mediterranean to man-made climate change with medium confidence (IPCC 2018). The UNCCD provided the following consensus definition of drought: "drought" means the naturally occurring phenomenon that exists when precipitation has been significantly below normal recorded levels, causing	Graham von Maltitz	South Africa	Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.
61289					It is not always clear where agriculture referes to crop agriculture versus rangeland management. In some instances it is clear from the context that the term refers only to crop agriculture, whilst in other places it appears it is used in a more generic form to also include animal management on rangelands.	Graham von Maltitz	South Africa	noted - addressed in part in chapt 7 , but lack of specification also reflects underlying literature
61291					The word savanna should be spelt without the H when referring to the vegetation type /biome.	Graham von Maltitz	South Africa	Noted. Thanks
61563					The term 'net zero emissions' and 'net zero' is used in the report without being defined. For example, chapter 11 and the technical summary. The glossary defines 'net zero CO2 emissions' and 'net zero GHG emissions'. It is requested that throughout the AR6 the terms 'net zero emissions' and 'net zero' are not used and only defined terms of 'net zero CO2 emissions' and 'net zero GHG emissions' are used.	Kent Buchanan	South Africa	Noted. Thank you for your comment. The term is now consistenly used in the report.
64813					There is alarming lack of diversity in composition of leading and contributing authors of the paper. There are no or minimum authors from Central and Eastern Europe, Russia, Kazakhstan, Japan, South Korea, Turkey, Egypt and Arabian countries involved. Specific geographical, environmental, social and economic situation and interrests of those regions may not be properly represented. Region - specific views and opinions might be missing in the paper, making it less complex and objective than expected. This may lead to difficult acceptance or even rejection of the IPCC outputs in those regions because of their objectivity and relevance might be questioned.	Radek Svoboda	Czech Republic	Noted
64815					The methodological approach of the paper is not clear. The goals, starting points, initial assumptions and boundary conditions, evaulation methodology and conclusions are not suffciently presented. Whole paper shows lack of systematic scientific approach, which might cause difficulties in acceptance by both policymakers and general public.	Radek Svoboda	Czech Republic	Noted
64817					Systematic evidence-based environmental impact assessment methodology of specific energy technologies and proposed GHG reduction pathways is missing in the paper. Environmental externalities shall be evaluated in a complex and systematic way using well-established and generally accepted methodology, e.g. ExternE, which has been developed for European Commission. http://www.externe.info/externe_d7/?q=node/6 Without objective and complex assesement, no consistent comparison of specific energy technologies can be performed and their real contribution to GHG reduction evaluated. Presented works seem to be less complex and sometimes subjective, while presented results lack adequate rationale	Radek Svoboda	Czech Republic	Noted. Chapter 6 uses a multi-attribute famework to evaluate mitigation options.

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65575					For a Report that aims at "building on the WG III contribution to the IPCC's Fifth Assessment Report (AR+I315) and the three Special Reports in the Sixth Assessment cycle Report (AR6)" the present draft lacks such connection/construction, particularly with respect to SROCC. The marine aspects of ecosystems (and their services), drivers, extreme events and their impact on the land component, those related to the role of marine and coastal environments in food security, services and coastal develpment. This shows a lack of assessement of the "literature on the scientific, technological, environmental, economic and social aspects of mitigation of climate change and the INTEGRATION of the current state of knowledge of all Reports building to this Sixth Assessment cycle. This is true for all other chapters and sections of the Report, particularly the SPM and TSumm.Very litte connection with biodiveristy aspects reported by of the IPBES Report (2019), particularly in regards to marine and costal realms as well as integration with the actions and goals for the UN Decade of Ocean Science for Sustainable Development. The UN is a big stakeholder on Global and Climate Change	Mônica M. C. Muelbert	Brazil	The report reviews a broad range of scenarios and options, many of which relate to the marine environment
66261					I have a general remark on the glossary on the definition of CCU which in my opinion is not appropriate and is incoherent with the use of CCU and CCUS throughout the whole report. In this version of the report, the term CCUS (Carbon Capture Utilisation and Storage) is often used but not clearly defined and in most cases, it discusses only Carbon Capture and Storage (CCS) technologies and not the utilisation phase. CSS and Carbon Capture and Use (CCU) distinctly differ regarding their CO2 reduction potential, the underlying technical processes and outcomes, their effects on climate mitigation, their business models and their environmental policy targets. Therefore, mixing the two concepts of CCS and CCU does not do justice to the specific characteristics of either and could be counterproductive for the further development particularly of CCU. Therefore the term CCUS should be separated in CCS and CCU and both options should be clearly addressed independently (Cuéllar-Franca and Azapagic, 2015, Bruhn et al., 2016, Arning et al., 2019). Please note that the definition formerly given of CCUS in the glossary (If the CO2 is stored in a product for a climate-relevant time horizon, is referred to as CO2 capture, utilisation and storage (CCUS)) is not correct and is incoherent with the use of the term CCUS in the report as in most cases CCUS is used in the context of Carbon Capture and (geological) Storage. The high level report of the Science Advice for Policy by European Academies (SAPEA) has explicitly mentioned that “measures, regulations and incentives should examine CCU in a holistic, integrated, coordinated and transparent manner » (SAPEA, 2018). Based on the references below, it is my proposal to have this as the definition of CCU: “Carbon Capture and Utilisation (CCU) is a broad term that covers all established processes that aim at capturing CO2 – either from industrial point sources, converted biomass or directly from the air – and at converting this captured CO2 into a variety of products such as e-fuels, chemicals and materials. CCU technologies can: • Reduce net CO2 emissions, help reaching zero emission targets and creating negative emissions when CO2 is captured directly from the air or biomass conversion and stored permanently into building material via mineralization processes • Replace fossil resources and thus support a transformation towards renewables in the energy, transport, chemical and material sectors • Stimulate the energy transition by enabling energy storage through power-to-X approaches • Contribute to develop a circular economy by converting waste emissions into resources Other terms such as CO2 transformation, CO2 conversion, CO2 recycling, CO2 valorization, or CO2 upcycling can also be used.” References: e.g. Styring et al., 2011, Ampelli et al., 2015, GCI, 2016, , Bushuyev et al., 2018, SAPEA, 2018, Hepburn et al., 2019, Breyer et al., 2019, Kätelhön et al., 2019, CCES, 2019.	Deepak PANT	Belgium	Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.
72187					In general, the whole report and the SPM are in a very good shape and I would like to thank the author team for all their hard work. I, however, want to highlight one major issue in my viewThe policy context of net-zero starts to play out highly problematically in climate policy largely due to the ambiguity of how to balance sources and sinks (see e.g. all kinds of companies coming forward with offset based net-zero targets). The report stumbles over several of the related issues. The NBZ zero IPs are quite strange, and the regional and sectoral net-zero timings just outright dangerous to present to policy makers, in my view. I therefore strongly suggest a critical reflection on the use of the net-zero concept and for all sub-global analysis a separation of emission reductions and removals. I would even go as far as to suggest the inclusion of a box in this chapter and possibly in the SPM on net zero	Carl Schleusner	Germany	Noted. Chapter 3 has been completely revised and most of the issues raised here are now also being addressed.
72495					Remarks on the glossary on the definition of CCU: The definition of the term CCU is not appropriate and is incoherent with the use of CCU and CCUS in the report. In the current version of the report, CCUS terminology (Carbon Capture Utilisation and Storage) is still used but it do not describe both the meaning. The term describes and discusses only Carbon Capture and Storage (CCS) technologies and not the utilisation phase. CSS and Carbon Capture and Use (CCU) distinctly differ regarding their CO2 reduction potential, the underlying technical processes and outcomes, their effects on climate mitigation, their business models and their environmental policy targets. CCS is functional to a linear economy, whereas utilization of carbon dioxide is at the hearth of a circular economy and its strategic role will grow in the future. (Nocito, et al (2020). Atmospheric CO2 mitigation technologies: carbon capture utilization and storage. Current Opinion in Green and Sustainable Chemistry, 21, 34-43; Dibenedetto, A. et al (2020). The Future of Carbon Dioxide Chemistry. ChemSusChem, 13(23), 6219-6228. Aresta, M. et al (2020). Carbon Recycling Through CO2-Conversion for Stepping Toward a Cyclic-C Economy. A Perspective. Frontiers in Energy Research, 8; Aresta, M., & Dibenedetto, A. (2021). The CO 2 Revolution. In The Carbon Dioxide Revolution (pp. 219-228). Springer, Cham.)	Angela Dibenedetto	Italy	Noted. Thanks

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74025					Comment concerning the definition of CCU in the glossary: The term CCUS is still used in the report. This term discusses only Carbon Capture and Storage (CCS) technologies and not the utilisation phase. CSS and Carbon Capture and Utilization (CCU) are distinct in what concerns their CO2 reduction potential, the underlying technologies, outcomes, their effects on climate mitigation, their business models and their environmental targets. Mixing the two concepts leads to unclear situations and harms CCU development. The high level report of the Science Advice for Policy by European Academies SAPEA (SAPEA, 2018, Science Advice for Policy by EU Academies, Novel Carbon Capture and Utilisation Technologies-Research and Climate Aspects, Evidence Review Report, 2) recommends: "measures, regulations and incentives should examine CCU in a holistic, integrated, coordinated and transparent manner". Therefore the term CCUS should be separated in CCS and CCU and both options should be clearly addressed independently in the report. (Cuéllar-Franca and Azapagic, 2015, J.CO2.Utili., 9, 82-102, Bruhn et al., 2016, Environmental Science & Policy, 60, 38–43, Arning et al., 2019, Energy Policy, 125, 235–249).The definition formerly given of CCUS in the glossary (If the CO2 is stored in a product for a climate-relevant time horizon, this is referred to as CO2 capture, utilisation and storage (CCUS)) is not correct and is incoherent with the use of the term CCUS in the report as in most cases CCUS is used in the context of Carbon Capture and (geological) Storage. For these reasons I propose the use of the following definition: "Carbon Capture and Utilisation (CCU) is a broad term that covers all established processes that aim at capturing CO2 – either from industrial point sources, converted biomass or directly from the air – and at converting this captured CO2 into a variety of products such as e-fuels, chemicals and materials. CCU technologies can: • Reduce net CO2 emissions, help reaching zero emission targets and creating negative emissions when CO2 is captured directly from the air or biomass conversion and stored permanently into building material via mineralization processes • Replace fossil resources and thus support a transformation towards renewables in the energy, transport, chemical and material sectors • Stimulate the energy transition by enabling energy storage through power-to-X approaches • Contribute to develop a circular economy by converting waste emissions into resources Other terms such as CO2 transformation, CO2 conversion, CO2 recycling, CO2 valorization, or CO2 upcycling can also be used.("Styring et al., 2011, Carbon Capture and Utilization in the Green Economy. Centre for Low Carbon Futures, York; Ampelli et al. 2015 Phil. Trans. R. Soc. A 373: 20140177; GCI, 2016 GCI, 2016: Global Roadmap Study of CO2U Technologies, LUX Research & Global CO2 Initiative;Bushuyev et al., 2018, Joule, 2(5) pp.825-832; SAPEA, 2018, Science Advice for Policy by EU Academies, Novel Carbon Capture and Utilisation Technologies-Research and Climate Aspects, Evidence Review Report, 2; Hepburn et al., 2019, Nature, 575, 87-97; Breyer et al., 2019, Joule, 3, 2053-2057, Kätelhön et al., 2019: Climate change mitigation potential of carbon capture and utilization in the chemical industry, PNAS, 116, 23, 11187-11194; CCES, 2019: Carbon Utilization – A vital and effective pathway for decarbonization, Center for Climate and Energy Solutions.	Ana Machado	Portugal	Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.
74333					I, Jeffrey S. Merrifield,have reviewed the entire report, and the comments referenced above represent my own personal opinons and were prepared solely by me with no outside assistance.	Jeffrey Merrifield	United States of America	Noted
74335					Overall, while there is much to be commended for the report, I am disappointed that the individuals preparing it vastly understated the current and potential role that nuclear power can play in addressing the issue of limiting global warming. The report relies too heavily on a view that wind and solar will be the principal technologies used to address these issues. While clearly, these technologies, when combined with appropriate bulk energy power storage (which are not currently widely available), could achieve 60-70% of the total power demands, nuclear and other low carbon capabilities including hydroelectric and CCS will be vital to provide baseload capabilities when the wind isn't blowing and the sun isn't shining. I further believe that the report could be modified to reflect these gaps and would be stronger and gain greater acceptablity were such changes to be made.	Jeffrey Merrifield	United States of America	Noted. Nuclear energy is included as a key low-carbon option in Chapter 6.
75677					Generally, the document is written in many its parts in the form of texts consist of only references, so it causes that it is more than problematic to understand what the text wants to express. The reader has no possibility to check all of references and to look for any information why the reference is included. That causes several consequences – normal people will not read it and thus will not follow those important thinks they are included. Less text with more clearly defined ideas and/or conclusions would be much more useful for readers.	Jiri Duspiva	Czech Republic	Thank you for your comment.
78553					About the glossary, the definition of CCU is not adapted and CCUS should be separated in CCS and CCU and both options should be clearly addressed independently (Cuéllar-Franca and Azapagic, 2015, Bruhn et al., 2016, Arning et al., 2019). The following definition of CCU would be much more adapted: "Carbon Capture and Utilisation (CCU) is a broad term that covers all established processes that aim at capturing CO2 – either from industrial point sources, converted biomass or directly from the air – and at converting this captured CO2 into a variety of products such as e-fuels, chemicals and materials. CCU technologies can: • Reduce net CO2 emissions, help reaching zero emission targets and creating negative emissions when CO2 is captured directly from the air or biomass conversion and stored permanently into building material via mineralization processes • Replace fossil resources and thus support a transformation towards renewables in the energy, transport, chemical and material sectors • Stimulate the energy transition by enabling energy storage through power-to-X approaches • Contribute to develop a circular economy by converting waste emissions into resources (Wich et al., 2020) Other terms such as CO2 transformation, CO2 conversion, CO2 recycling, CO2 valorization, or CO2 upcycling can also be used." References: e.g. • Styring et al., 2011, Carbon Capture and Utilization in the Green Economy. Centre for Low Carbon Futures, York.,• Ampelli et al., 2015, Phil.Trans.R.Soc.A, 373., • GCI, 2016: Global Roadmap Study of CO2U Technologies, LUX Research & Global CO2 Initiative., ,• Bushuyev et al., 2018, Joule, 2(5), pp.825-832. • SAPEA, 2018, Science Advice for Policy by EU Academies, Novel Carbon Capture and Utilisation Technologies-Research and Climate Aspects, Evidence Review Report, 2. • Hepburn et al., 2019, Nature, 575, 87-97. Breyer et al., 2019, • Kätelhön et al., 2019, PNAS, 116, 23, 11187-11194. • CCES, 2019: Carbon Utilization – A vital and effective pathway for decarbonization, Center for Climate and Energy Solutions.. • Arning et al. 2019, Energy Policy, 125, 235–249.• Bruhn et al., 2016, Environmental Science & Policy, 60, 38–43. • Cuéllar-Franca and Azapagic, 2015, J.CO2.Utili., 9, 82-102.• Wich et al. 2020, Frontiers Energy	Sylvain Nizou	France	Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.

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78579					the wording 'CCUS' is highly misleading and shall be split to 'CCU' and 'CCS'. Both concepts are highly different, and it is increasingly found in research that they are applied in a strongly opposed manner: CCU corresponds with Power-to-X and low-cost renewable electricity, while CCS is linked to fossil fuel use and the implicit assumption/input of high-cost renewable electricity. More can be found in Breyer et al. (https://www.cell.com/joule/fulltext/S2542-4351(19)30413-1) and Bruhn et al. (https://www.sciencedirect.com/science/article/pii/S1462901116300508)	Christian Breyer	Finland	Thank you for your comment. These concepts have been separated as far as possible in the report, where the literature makes a distinction
79695					Though nuclear energy is recognized by IPCC as a low carbon source of energy, and appears in the very large majority of 1.5°C pathways from SR15, it is barely mentioned and often not mentioned at all in large parts of the report, specially executive summaries, as if it was not needed to reach objectives	valerie faudon	France	Noted. Nuclear energy is included as a key low-carbon option in Chapter 6.
79697					Chapter 6 does not contain any information on how nuclear performs on SDGs, though three substantial reports have been written by IAEA (a UN agency) on the topic: 1/ https://www.iaea.org/sites/default/files/np-sustainable-development.pdf (2017) 2/ https://www.iaea.org/bulletin/57-3 (2016) 3/https://sustainabledevelopment.un.org/content/documents/2259iaeasdg-brochure_forweb.pdf (2015). Recently a report has been published by UNEFE https://unece.org/sustainable-energy/publications/nuclear-entry-pathways. Information on nuclear in chapter 17 on nuclear in SDG, does not reflect the existing litterature	valerie faudon	France	Noted. Chapter 6 does not survey the SDG impacts of all options, but focuses instead on broader strategies and SDGs. At the same time, Chapter 6 does use a multi-dimensional framework to evaluate mitigation options.
79699					Chapters 3,4,6 do mention 100% renewable scenarios without addressing enough the challenges they represent in terms of feasibility. From an IPCC point of view, priority attention should be given to the robustness of pathways and their certainty in reaching the goals. See recent report from IEA/RTE on France: https://www.iea.org/news/rte-and-iea-publish-study-on-the-technical-conditions-necessary-for-a-power-system-with-a-high-share-of-renewables-in-france-towards-2050: “Apart from small systems mainly based on dispatchable hydroelectric units, there is no experience of operating such systems”../.. given that there is no proof of concept regarding the integration of high shares of variable renewables –such as wind and solar PV- in large power systems, technical challenges are bound to come up.” -“Even if one or more scenarios may appear technically feasible, any conclusions on their socio-economic desirability would thus require further analysis.”	valerie faudon	France	Noted. Chapter 3 has been completely revised and most of the issues raised here are now also being addressed.
83683					it is highly important to point out that IAMs structurally underestimate the role of solar PV as a major, if not THE major, energy source for climate change mitigation and zero emission systems. Most recent literature has clearly and statistically validated emphasised that most important claim - see Jaxa-Rozen (https://www.nature.com/articles/s41558-021-00998-8). However, this has been also document with different methods by Victoria et al. (2021, Solar photovoltaics is ready to power a sustainable future, Joule, in press), also detailing reasons why IAMs structurally underestimate the role of solar energy and why non-IAMs can generate different insights. The same has been pointed out earlier, but in less powerful methods by Creutzig et al. https://www.nature.com/articles/nenergy2017140, Breyer et al. https://onlinelibrary.wiley.com/doi/10.1002/pip.2885 and Vartiainen et al. (https://onlinelibrary.wiley.com/doi/full/10.1002/pip.3189) - in particular highlighting the structurally outdated solar PV cost assumptions which leads to severe distortions in results of IAMs	Christian Breyer	Finland	Noted. Chapter 3 has been completely revised and most of the issues raised here are now also being addressed.
83743					The role of CO2-based fuels also called synthetic fuels, e-fuels or powerfuels is acknowledged in the IPCC AR6 WGIII SOD, but the related references and major statements do not reflect the state-of-the-art of the literature on this subject. In the current version, CO2-based fuels are not considered as drop-in solutions and their deployment is considered as unlikely in the near to mid-term. This statement does not reflect the technology advancements presented in the recent literature nor the readiness level of numerous CO2 to fuel projects all over the world. To give a concrete example, the first flight using e-kerosene has started flying early 2021 in the Netherlands (https://www.transportenvironment.org/news/first-passenger-flight-performed-using-clean-fuels-sort). CO2-based fuels can find a role in sectors that are harder to decarbonize, such as aviation, shipping and energy intensive industries since hydrocarbons have volumetric energy densities that are orders of magnitude above those of hydrogen and present-day batteries (e.g. Dimitriou et al., 2015, Schmidt et al., 2017, Hepburn et al., 2019, DENA-Powerfuels in Aviation, 2019). The long-term use of carbon based energy carriers in a net zero emissions economy relies upon their production with renewable energy, and upon low-cost, scalable, clean hydrogen production, e.g. via the electrolysis of water. The estimated potential for the scale of CO2 utilization in fuels varies widely, from 1 to 4.2 Gt CO2 yr−1, reflecting uncertainties in potential market penetration. The high end represents a future in which CO2-based fuels have sizeable market shares, due to cost reductions and policy drivers (Hepburn et al., 2019). In the near-term (2030), the CO2 used to produced alternative fuel will mainly come from point sources (e.g. Farfan et al.,2019), while in the mid-term (2040), it will come from direct air capture (DAC) (RAM et al., 2020, Breyer et al., 2019, Drechsler and Agar, 2021). Life-cycle analysis demonstrate that both point source and DAC to fuel pathways can provide climate benefit over conventional diesel fuel if a low carbon source of electricity is used (e.g.Daggash et al., 2018, CONCAWE, 2019, Liu et al., 2020,). The chances for these CO2-based fuels to succeed will strongly depend on their compatibility with existing technology and infrastructure, with the growth and price of renewable energy and with the development of appropriate policy and market incentives (Grim et al., 2020). Despite these challenges, most of the boundary conditions (fuel composition, price, feedstock) for near- and medium-term deployment of CO2-based fuels are clear; now, it is a matter of finding the most economical route towards the synthesis of these fuels (Ramirez et al., 2020). In term of technologies, recent advances in the CCU field offer untapped potential for the realization of CO2 conversion to fuels. Today, a large palet of technologies exist, some are close to commercialization, others are at the benchtop/pilot scale, and some have yet to be scientifically proven. Thermochemical and bioelectrochemical routes offer the most technically feasible near-term opportunities for CO2-based fuels, representing immediately deployable pathways to high-value and relatively high-volume products. These pathways are the closest to commercialization and are ready to be upscaled in near-term (5-10 years) while other routes such as the direct electrochemical pathways are promising on the long-term but will take several decades to overcome the current technical barriers (Diaz et al., 2018, Messias et al. 2019, Edwards et al., 2019, Bushuyev et al., 2020, Masel et al., 2021). Close to 50 high Technology Readiness Level (TRL) projects on CO2 to fuel exist in Europe and many of them will reach commercialisation in the near-term (before 2030). Please find a few examples below with the forecasted production of CO2-based fuel in near-term (within 5 years): -Norsk-efuel (DAC to jet-fuel)=> 100 Million ton of jet-fuel/year -Carbon Recycling International => 4000 tons of methanol/year -Jupiter 1000 (CO2 flue gas to CH4) : 25Nm3/h of methane	Christian Breyer	Finland	Noted

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83749					The role of CO2 mineralisation as climate mitigation option and enhancer of circular processes for the industry should be cited in Chapter 11.]. Carbon mineralization is an emerging approach to remove CO2 from the air and/or store it under the form of carbonate minerals into building materials. Originally, mineralization is a natural process occuring on geological time-scale during the weathering of silicate materials and rocks rich in Ca and Mg, coming from the Earth's upper mantle. Because it utilises this naturally available chemical energy, this method may offer a low cost means to mitigate greenhouse gas emissions and lock CO2 into solid carbonate minerals, in a permanent and nontoxic way (e.g.Zevenhoven and Fagerlund, 2010, Giannoulakis et al., 2014, Cuéllar-Franca et Azapagic, 2015, Kaliyavaradhan et al., 2017, NAS, 2019, Huang et al., 2019, Lee et al., 2020, Pan et al., 2020). The conversion of CO2 into carbonates may offer a potential to convert low value materials into useful products, namely concrete, asphalt and construction fill." (SAM, 2018)A promising pathway is to let CO2 react with mineral- rich industrial wastes (e.g. concrete debris) to create new building material.This circular concept allows to decrease CO2 emissions and landfills, but also to sequested CO2 permanently in valuable products (e.g. Khoo et al., 2011, Xuan et al., 2016, Ebrahimi et al., 2017, Pasquier et al., 2018, Zhang et al., 2020, Tripathi et al., 2020). Moreover, mineralisation of CO2 into cementitious materials improves upon material quality by densifying and reducing water absorption of such materials whilst permanently imprisoning CO2 (Tam et al., 2020) Ostovari et al., 2020 have shown that all considered CCU technologies for mineralization could reduce climate impacts over the entire life cycle based on the current state-of-the-art and today's energy mix. Reductions range from 0.44 to 1.17 ton CO2e per ton CO2 stored. For all mineralisation pathways evaluated, the carbon footprint is mainly reduced due to the permanent storage of CO2 and the credit for substituting conventional products. Thus, developing suitable products is critical to realize the potential benefits in practice. Then, carbon capture and utilization by mineralization could provide a promising route for climate change mitigation. Current data suggests that up to 1 Gt per year of the cement market could be substituted by mineralization products. Di Maria et al., 2020 conducted an LCA of carbonated steel slag including CO2 capture and confirm that mineralization is a negative-carbon-footprint technology, since the amount of CO2 taken up and stored during the process is higher than the amount of CO2 emitted, considering the whole life cycle. While comparing the findings to Portland cement concrete blocks, they report GHG emission reductions of up to 77%. At endpoint, they report that concerning the damages to human health and ecosystems, the carbonated blocks have a lower impact compared to the traditional PC-based concrete, and an overall positive environmental impact. The manufacture of carbonated aggregates starts to be commercially established at global scale, and recent advances in technology include a mobile plant that directly utilizes flue-gas derived CO2 in the mineralisation process in the UK (Hills et al., 2020). At mid-term, direct air capture combined with CO2 mineralisation could allow creating negative emissions as CO2 will be removed from the atmosphere and store permanently in materials (e.g. SAPEA, 2018, Beuttler et al., 2019, Breyer et al., 2019). ((e.g. SAPEA, 2018, Beuttler et al., 2019, Breyer et al., 2019).•Giannoulakis et al., 2014, International Journal of GHG Control, 21, 140-157.•Beuttler et al., 2019, Frontiers n Climate, 1 :10.•Breyer et al., 2019, Joule, 3, 2053-2057.•Di Maria et al, 2020, International Journal of Greenhouse Gas Control, 93.•Ebrahimi et al., 2017, J. of Cleaner Production, 156, 660-669.•Cuéllar-Franca and Azapagic, 2015, J.CO2.Utili., 9, 82-102.•Huang et al., 2019, J. of Cleaner Production, 241, 118359.•Lee et al., 2020, J. CO2. Util., 37, 113-121.•NAS, 2019, Negative Emissions Technologies and Reliable Sequestration, The National	Christian Breyer	Finland	Noted

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83753					Carbon Capture and Utilisation (CCU) is now considered as a solution to mitigate climate change in the IPCC AR6 WGIII SOD, however its definition and several key messages need to be refined to reflect the literature. CCUS is barely used anymore, but CCU and CCS are still mixed sometimes, especially when discussing the barriers and needs of CCS, which does not do good to CCU as the barriers and needs are not the same. CCU technologies are available now and offer solutions to reduce net CO2 emissions with an estimated potential impact of gigatons equivalent CO2 emissions. Indeed, CCU technologies have the potential to utilize up to 8 Gt of CO2 per year by 2050 (GCI, 2016, Hepburn et al., 2019), this is equivalent to approximately 15% of current global CO2 emissions. Moreover, When CO2 is captured directly and stored permanently via mineralization into building materials, CCU can also create negative emissions (e.g.Di Maria et al., 2020, Ostovari et al., 2020). Unlike other options, CCU technologies provide drop-in solutions which can be implemented without requiring significant modification of existing production, distribution and use infrastructure (e.g. Ampelli et al., 2015, Hepburn et al., 2019). Another important asset of CCU technologies is the utilisation of CO2 as carbon feedstock to replace fossil resources (e.g. Sternberg et al., 2017, Daggash et al., 2018, Kätelhön, et al., 2019, Thonemann, 2019) and support the development of a circular economy, e.g. when CO2 is used together with industrial wastes to create materials (e.g. Di Maria et al., 2020, Ostavari et al., 2020). CCU technologies have the potential to provide solutions to hard-to-abate sectors, but also to generate revenues through producing marketable products (e.g. Hepburn et al., 2019, Zhu, 2019). Because of their lack of granularity, Integrated Assessment Models (IAM's) have yet failed in simulating the complexity of the different CCU options to realize net zero or negative CO2 emissions (e.g. Detz and Zwaan, 2019). Consequently, no exhaustive quantification exists today on the climate mitigation potential of this large panel of technologies. However, their key role should be considered as one building block in a portfolio of mitigation measures (e.g. Wilson et al., 2016, GCI, 2016, Grüber et al., 2018, IEAGHG, 2019b, Detz and Zwaan, 2019). Following the CCU concept, CO2 can be captured at point sources or directly from the atmosphere and subsequently converted into valuable products such as building materials, chemicals, synthetic fuels (e.g. Styring et al., 2011; von der Assen et al., 2013, SAPEA, 2018, Kätelhön et al., 2019). The duration of the CO2 storage into a product strongly varies from days to millenia according to the applications. However, in term of environmental assessment, CCU technologies should not be assessed only with respect to the amounts of CO2 that can be used nor to its storage duration, but rather it is essential to determine the life cycle of the CO2-based product generated (e.g. Bruhn et al., 2016, Zimmerman et al., 2018, Nocito and DiBenedetto al., 2020). If these products are assumed to be substitutes for fossil-based products and thus provide the same service (i.e. it would be used and disposed of according to the same patterns as conventional products), the focus of the life-cycle-analysis may lie in the cradle-to-gate phase (e.g. Kätelhön, et al., 2019). Two important points should however be highlighted (Arning et al., 2019, IEAGHG, 2019b, Zhu, 2019): 1)If CO2-based products can be produced with less environmental impact (including GHG emissions) than fossil-based ones, an environmental benefit can be asserted, independent of the storage time of CO2 in the products. 2)If CO2-based products are recycled i.e. if their end of life CO2 emissions are captured to generate new products, the duration of CO2 storage in a product is not anymore crucial to consider in the life cycle analysis.	Christian Breyer	Finland	Noted. In Chapter 6, CCS is use to capture the idea of storing carbon for long periods of time. Many forms of CCU do not actually store carbon for meaningful amounts of time, and many do. So it is not viable to discuss CCUS as a solution without raising concerns that this includes forms of CCU that will not store carbon.
83765					Remarks on the glossary on the definition of CCU: The definition of the term CCU is not appropriate and is incoherent with the use of CCU and CCUS in the report. In the current version of the report, the term CCUS (Carbon Capture Utilisation and Storage) is still used at some places but not clearly defined and in most cases, this term discusses only Carbon Capture and Storage (CCS) technologies and not the utilisation phase. CSS and Carbon Capture and Use (CCU) distinctly differ regarding their CO2 reduction potential, the underlying technical processes and outcomes, their effects on climate mitigation, their business models and their environmental policy targets. Therefore, presenting commingling CCS and CCU does not do justice to the specific characteristics of the two concepts and could be counterproductive for the further development particularly of CCU. Therefore the term CCUS should be separated in CCS and CCU and both options should be clearly addressed independently (Cuéllar-Franca and Azapagic, 2015, Bruhn et al., 2016, Arning et al., 2019). Please note that the definition formerly given of CCUS in the glossary (If the CO2 is stored in a product for a climate-relevant time horizon, this is referred to as CO2 capture, utilisation and storage (CCUS)) is not correct and is incoherent with the use of the term CCUS in the report as in most cases CCUS is used in the context of Carbon Capture and (geological) Storage. The high level report of the Science Advice for Policy by European Academies (SAPEA) has explicitily said: " measures, regulations and incentives should examine CCU in a holistic, integrated, coordinated and transparent manner » (SAPEA, 2018). Based on the references below, I propose the following definition of CCU: "Carbon Capture and Utilisation (CCU) is a broad term that covers all established processes that aim at capturing CO2 – either from industrial point sources, converted biomass or directly from the air – and at converting this captured CO2 into a variety of products such as e-fuels, chemicals and materials. CCU technologies can: •Reduce net CO2 emissions, help reaching zero emission targets and creating negative emissions when CO2 is captured directly from the air or biomass conversion and stored permanently into building material via mineralization processes •Replace fossil resources and thus support a transformation towards renewables in the energy, transport, chemical and material sectors •Stimulate the energy transition by enabling energy storage through power-to-X approaches •Contribute to develop a circular economy by converting waste emissions into resources (Wich et al., 2020) Other terms such as CO2 transformation, CO2 conversion, CO2 recycling, CO2 valorization, or CO2 upcycling can also be used." References: e.g. •Styring et al., 2011, Carbon Capture and Utilization in the Green Economy. Centre for Low Carbon Futures, York.,•Ampelli et al., 2015, Phil.Trans.R.Soc.A, 373., •GCI, 2016: Global Roadmap Study of CO2U Technologies, LUX Research & Global CO2 Initiative., ,•Bushuyev et al., 2018, Joule, 2(5), pp.825-832. •SAPEA, 2018, Science Advice for Policy by EU Academies, Novel Carbon Capture and Utilisation Technologies-Research and Climate Aspects, Evidence Review Report, 2. •Hepburn et al., 2019, Nature, 575, 87-97. Breyer et al., 2019, •Kätelhön et al., 2019, PNAS, 116, 23, 11187-11194. •CCES, 2019: Carbon Utilization – A vital and effective pathway for decarbonization, Center for Climate and Energy Solutions.. •Arning et al. 2019, Energy Policy, 125, 235–249.•Bruhn et al., 2016, Environmental Science & Policy, 60, 38–43. •Cuéllar-Franca and Azapagic, 2015, J.CO2.Utili., 9, 82-102.•Wich et al. 2020, Frontiers Energy Research, 7, 162.	Christian Breyer	Finland	Thank you for your comment. There has been a comprehensive coordination effort across the AR6 to ensure the definitions are consistent across the three Working Groups. The current definitions accurately reflect how the term is used in the reports.

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84161					In my opinion also the IPCC AR6 Climate Change 2021: Mitigation of Climate Change (WGIII) SOD is excellent, clear and date driven.	Mario Valentino Romeri	Italy	Thank you for the postive comment
84163					Also in the WGIII SOD I had particularly appreciate the properly consideration give to hydrogen energy carrier and fuel cell technologies a 'game changer' in fighting climate change, according to what I wrote in my paper "The history could repeat itself: hydrogen-oxygen fuel cell is the 'game changer'" [published January 2020 in "4th AIEE Energy Symposium Conference Proceedings" Rome, available at <http://www.aieeconference2019rome.eu/documents/AIEE_Symposium_Proceedings_4.pdf>], in my presentation "Hydrogen and fuel cell: looking back to 20 year of professional experience and looking forward beyond 'Covid-19' and toward '1.5° C Perspective'" [available at <https://www.aieesymposium.eu/wp-content/uploads/2020/12/ROMERI-.pdf>] and according to "Box 12.3 Hydrogen in the context of cross-sectoral mitigation options" affirmation: "The interest in hydrogen as an intermediary energy carrier has rapidly grown in the years since 5th Assessment Report of WGIII (AR5) was published. This is reflected in this WGIII assessment report in which the term 'hydrogen' is used more than five times more often than in AR5 [see "Chapter 12: Cross-sectoral perspectives", page 12-95, lines 20-23]	Mario Valentino Romeri	Italy	Noted. Chapter 6 extensively discusses the role of hydrogen.
85247					Congratulations for the WGIII SOD. There are a number of opportunities for enhanced integration with WGI, including framing mitigation in the context of a changing climate and the associated implications and for avoiding as much as possible the use of CO2-equivalent but provide explicit information on the mitigation potential gas per gas. Please note that many of my comments provided to the SPM are also relevant for the corresponding chapters. Due to time constraints (and the completion of the WGI report), I have focused my comments on the SPM and TS.	Valérie Masson-Delmotte	France	Thank you. Accepted, Checked for consistency
85285					My remarks are restricted to the SPM and TS but they have implications for chapters. I summarize here a few key concerns : how do the various chapters incorporate the fact that we are living in a fast changing climate in their assessments? (eg how will changes in mean climate, extremes, values above thresholds, will provide constraints and affect the feasibility, potential, of options, or the demand side, for instance the cooling demand). There is a potential for enhanced coherency and clarity with the WGI report by providing as much as possible information for the mitigation of each GHG (CO2, CH4, etc) and on aspects related to remaining carbon budgets. I place an emphasis on CH4 due the sharp rise in emissions and due to its role as the second most important driver of the Earth's energy imbalance after cumulative CO2 emissions (eg. methane emissions in the energy sector). I also stress the fact that the TS and SPM do not cover gender aspects (while there is literature on gender dimensions related to mitigation as well as on just transitions). I am wondering how air quality aspects will be addressed in the SYR given limited information in WGIII and WGII currently (while this is a very important health concern). Finally, I am suggesting to consider the importance of education, teaching, lifelong training, and transparency of GHG emission information for consumers amongst the enabling conditions for behaviour change.	Valérie Masson-Delmotte	France	Accepted. Thank you for the comments. Checked for consistency and coherency on CH4 and other GHGs with WGI report. Chapters redrafted to provide stronger links to WGI and WGII reports SPM & TS redrafted to cover gender aspects, air quality aspects and enabling conditions for behaviour change.
85351					While recognizing the tremendous efforts made to complete the Second Order Draft of the WGIII contribution to the IPCC Sixth Assessment Report, and the importance of the scientific evidence brought forward by the IPCC on all sectors, from a technical perspective, we are concerned on some of the sources and scope of data used, as well as the range, quality and uncertainties associated with some of the statements made in the report. Additional concern is related to the focus on the CO2 emission from specific sectors and the indication that some sectors are "high emitting", without clarifying clearly what this means in the context of either total emissions or emissions rates from all sectors, including those outside of transport. To be fair and equitable across all sectors, the data used, uncertainties and clear definitions would be beneficial to the scientific understanding of the report, and for the prioritization of further scientific analyses focused on specific sectors. There is also concern regarding statements throughout the report, which appear to be more politically driven, rather than underpinned by data- or a complete overview of the scientific literature. We would like to express hope that a review will be conducted of such statements (they ae indicated in the comments table), using the relevant data form the various sectors on the opportunities to reduce CO2 emissions, and that it will be clearly articulated in the report the sectors, such as aviation, that have a well developed forum, and strategies for reducing CO2 emissions.	Neil Dickson	Canada	Noted. Thank you for your comment. Chapter 2 Supplementary Material has detailed analysis on data sources and uncertaitnies.
86229					SLCFs are defined as species having relatively short lifetimes (from hours to decades) and climate effects predominantly in the first two decades after their emission or formation (note that presursors of SLCFs are included in SLCFs). It means that CH4 is part of SLCFs and some HFCs too. This is the way it is treated in the chapter dealing with SLCF in WG1 (chapter 6) but not systematically here where SLCFs are essentially the compounds related to ozone and aerosols (e.g: in chapters 2, 4 and 10 and in TS).	Sophie Szopa	France	Noted. Thank you for your comment. This has now been clarified in the report.
86249					Annexe A - Glossary, the SLCF definition can not be different from the one in WG1	Sophie Szopa	France	Accepted. The definitions have been harmonised across the Working Groups
86513					I think it would be better if the report concentrate more on how extra cost we would have to pay when appropriate response such as energy transition is dealyed. As Michal Mann suggested in his book Climate War, it is important to stress the urgency and the agency that we have a good chance to avoid climate disaster. I think it is important to stress that we, our generation, would be responsible for massive sacrifices of human races and various life forms in vulnerable areas in the future when we delay the appropriate response. The scale of sacrifice could be larger than the genocides and the casulaties of the World Wars in the 20th centuries. It would be quite essential to stress the importance cumplsary systems such as carbon tax. There is an appropriate amount that IMF determined.	Kim Yong Yook	Republic of Korea	Noted. Chapter 3 discusses delay in some detail. Chapter 6 does also briefly discuss the impacts of delay.
86695					There are different views of biomass and hydrogen in the different sections I read (Transport, energy, buildings, and probably industry and innovation as well, though I did not have time to explore this) and these need tying together to tell a consistent story across the chapters.	Mark Hinnells	United Kingdom (of Great Britain and Northern Ireland)	Noted.
86697					The same is true of biomass. The available biomass or waste resource is at risk of being used multiple times, whereas it probably starts in one of the key technical niches, and will see most uptake where its most valuable.	Mark Hinnells	United Kingdom (of Great Britain and Northern Ireland)	Noted.

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86699					For biomass or plant based resources, if we get the policy framework for aviation right, the most valuable use of this resource will be in production of what is euphemistically called “Sustainable Aviation Fuel”, or in high temperature industry, but probably not in electricity, for which there are other solutions	Mark Hinnells	United Kingdom (of Great Britain and Northern Ireland)	Noted.