Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
28779	0	0	0	0	Overall, the food system section (12.4) is much improved from the First Order Draft and provides a more balanced and holistic description of food systems and climate change.	**Noted.** Thank you.	Erin Biehl	Johns Hopkins Center for a Livable Future	United States of America
46139	0	0	0	0	Section with knowledge gaps is missing. We kindly urge the authors to add this important information. Please see our general comment on knowledge gaps.	Accepted. We have mentioning of knoweledge gaps throughout the different sections. A new section in the introduction (i.e., 12.1.4) is added to specifically assess the knowledge gaps.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
46141	0	0			It is well appreciated that topics like substitution (of fossil fuel-intensive materials through e.g. biomass) and multi-purpose forest management (A/R not only for C sequestration) are finally fully acknowledged in an IPCC AR.	Noted.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
14967	0				Chapter 12 is the home of the crucial CDR assessment. Please make sure that every single available option be it land or ocean based is assessed and presented in detail. Currently, risks associated with individual approaches are not adequately highlighted. Please revise and include information more comprehensively in the ES as well.	Noted. Land based options are discussed in Ch7. We summarise in the table but refer the reader to Ch7 for description of land based options	Government of Saint Kitts an	Department of Environment - Ministry of Agriculture, Marine Resources, Cooperatives, Environment and Human Settlements	Saint Kitts and Nevis
22299	0				Please consider this suggestion: "Ocean based approaches" would be clearer if the three methods were distinctly separated and each time described and associated it with its potential, risks and costs. Especially as the last one, blue carbon, is more a solution based on nature.	Noted: Already separated in text and table, no space to do it in more details	Government of France	Ministère de la Transition écologique et solidaire	France
22301	0				policy recommendation ocean approaches come with a “medium confidence” evaluation (“Ocean-based approaches have the potential to remove 1–100 GtCO2 yr-1 at costs of 40 -500 USD tCO2-1 (medium confidence).”), while SROCC concluded on a “low confidence”. Despite the fact that the information is not exactly the same, the message simply taken is a global shift for these techniques from low confidence to medium confidence. Could you please double check the justification for it and maybe make it more explicit?	Taken into account: ES text is revised by including information about unsertain feasibility of ocean-based CDR approaches and possible side-effects. More details are in the ch.12.3	Government of France	Ministère de la Transition écologique et solidaire	France
22303	0				most of the rationale to develop Ocean Alkalinity enhancement and Ocean Fertilization seems to come from GESAMP report. That states: “For each and every technique, information on marine geoengineering approaches available in the permanent public record, and/or as peer-reviewed documents, is inadequate to permit a robust scientific assessment, much less one that can be readily intercompared with other approaches to climate intervention.” (p12). Could you consider underlining the risk and the call for more research before implementing those solutions at major scale. Furthermore, for OF and OA this paragraph underlines the risk regarding the use of the technology, i.e. the potential adverse impacts of artificial OF and OA on the global functioning of marine ecosystems. On the other hand when we read this paragraph for BC the risk is associated to the potential destruction of those ecosystems that would release carbon. This impression is increased in the Table 12.6	Taken into account: agree with underlining the risk and the call for more research. It is integrated in the text	Government of France	Ministère de la Transition écologique et solidaire	France
31055	0				Military contributions to greenhouse gas emissions are missing from Chapter 12. Since global military emissions are so large, a detailed treatment ought to be included here. It’s absence erodes trust in the ability of the report to do its work.	Rejected. The military sector is important but it is outside the scope of chapter 12.	Daniel Helman	College of Micronesia-FSM	Micronesia, Federated States of
31445	0				Chapter 12 is the home of the CDR assessment of WGIII and it is important that a more comprehensive assessment is carried out, in particular in term of risks, in the relevant sections, with more specific information also elevated to the ES. CDR is at the heart of all pathways in line with the Paris Agreement goal, so it is crucialy important to fully capture potentials and risks of every single approach discussed in the literature. Please elaborate on limitations and risks of ocean-based CDR measures, for example, as they are especially controversial in terms of impacts on marine ecosystems. Please expand the CDR chapter assessment.	Noted; the assessment of each CDR option has been revised and harmonised; the final draft gives as much space to each option as we feel we can justify within existing wording constraints, literature, and their treatment in other IPCC reports	Government of Palau	Government	Palau
47451	0				The assessment of risks associated with individual CDR approaches and how these increase with the scale of deployment for the different options has to be better captured in this chapter. Please elaborate on the uncertainties related to the potentially sustainable scale of deployment. In particular, it should be highlighted that the ocean-based CDR options are especially risky in terms of potential impacts on marine ecosystems, apart from having no legal basis for deployment.	Noted; the assessment of each CDR option has been revised and harmonised; the final draft gives as much space to each option as we feel we can justify within existing wording constraints, literature, and their treatment in other IPCC reports	Government of Saint Lucia	Department of Sustainable Development - Ministry of Education, Innovation, Gender Relations and Sustainable Developement	Saint Lucia
61841	0				The chapter refers to “renewable energy” throughout in regards to climate mitigation, even though it would be much more accurate and scientifically correct to use “low carbon”. Renewable energy includes unsustainable and problematic – even high climate impact – energy sources while it also excludes one of our most potential low-carbon energy source nuclear energy. See more on the problems of the term “Renewable energy” and why “low carbon” should be used instead from Harjanne and Korhonen, 2018, https://doi.org/10.1016/j.enpol.2018.12.029	Accepted. We have already corrected the usage in section 1 by replacing "renewable" with "low carbon" where relevant and will follow up in other sections as appropriate.	Rauli Partanen	Think Atom	Finland

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
64881	0				This chapter consistently uses the term 'afforestation / reforestation'. This includes a variety of situations which need to be distinguished. Planting trees in formerly forested land - reforestation - can have many benefits for mitigation, biodiversity, adaptation and ecosystem services. Planting trees in areas which would not naturally support forest cover, for example savannas (which only have sparse tree cover) or some temperate peatlands can damage biodiversity, hinder mitigation and even lead to net emissions (e.g. where peatlands are drained). It is important to distinguish between these situations. I accept that the term afforestation is sometimes used for situations where tree cover has been lost many centuries, nevertheless using it in those circumstances can create problems in other contexts. There are also more benefits for biodiversity where species native to a particular area are planted. (I have made this point in other chapters. As CLA for the terrestrial and freshwater ecosystems chapter of Working Group II, I am keen to ensure there is consistency between WGII and WGIII reports and am happy to work with you on this.	Rejected: This chapter collates information on CDR from Ch7 where both afforestation and reforestation are discussed. We recognise the different implications, but we are reporting cost and potentials reported in Ch7 here	Michael Morecroft	Natural England	United Kingdom (of Great Britain and Northern Ireland)
72779	0				Please reference Mace Global Policy (forthcoming) Large-scale carbon dioxide removal to meet the 1.5°C limit: key governance gaps, challenges and priority responses; and Fyson, C. L., Baur, S., Gidden, M., & Schleussner, C. F. (2020). Fair-share carbon dioxide removal increases major emitter responsibility. Nature Climate Change, 10(9), 836-841.	Taken into account: both these references are relevant for CDR governance and Mace et al., 2021 is cited in the section 12.3.3 CDR governance and policies	Matthew Gidden	Climate Analytics	Germany
74921	0				The chapter does ot cover much on Ocean as a sector that contributes to miigation	Noted: agree, but no space to do it in more details	Government of Kenya	Kenya Meteorological Service	Kenya
76911	0				The acronym TRL (technology readiness level) is used several times in this chapter but it is apparently not spell out. For clarity, please either refrain from using the acronym, or spell it out. In addition, technological readiness levels might benefit from a definition in the chapter and/or glossary.	Accepted. The term is now spelled out at first use in the text.	Philippe Marbaix	Université catholique de Louvain	Belgium
10997	1	1	113	8	I recommend to use "$/tCO2" and "../year" instead of "…CO2-1" and "…year-1" to keep the constiency among chapters	Taken into account. editorials will be applied subject to consistency requirement across the whole report	Dong-Woon NOH	Korea Energy Economics Institute	Republic of Korea
16595	1	1	113	8	I recommend to use "$/tCO2" and "../year" instead of "…CO2-1" and "…year-1" to keep the constiency among chapters	Taken into account. editorials will be applied subject to consistency requirement across the whole report	Government of Republic of K	Korea Meteorological Administration (KMA)	Republic of Korea
11867	1	36	1	45	No link to the effect on Carbon sink potential with grassland crops in Land use can make this information biased on terms of potential.	**Rejected.** The text doesn't go into the details of individual emissions sources/sinks, but is rather linked to overall assessment considering all data available.	The Royal Swedish Academy	Kung. Skogs-och Lantbruksakademien	Sweden
57685	4	1	6	43	The Executive Summary section is very long and would benefit from being written more succinctly.	Taken into account. An attempt is made to shorten statements and make them more concize	Government of United State	U.S. Department of State	United States of America
65593	4	1	187	3	Consider using and acknowledging the evidence produced by IPCC-SROCC given the importance of Ocean and Cryosphere on Climage Change. Ocean alkalinity, ocean fertilisation, fisheries and marine ecosystems need stronger cross-referencing and be evidenced under a cross-sectoral perspective. Check definitions such as "blue carbon" with other IPCC glossaries for consistency. The chapter should acknowledge the importance of the Oceans as a source of carbon sink throughout the text and figures/tables.	Accected. We have referred to IPCC SROCC in the sections on ocean based approaches	Mônica M. C. Muelbert	UNIFESP	Brazil
80213	4	1	4	1	The executive summary of Ch12 is missing a discussion of SRM as identified in Ch1.	Rejected. SRM is outside the scope of chapter 12. SRM is considered as a cross-working groups issue, the governance part of it is dealt with in chapter 14.	Kelly Wanser	SilverLining	United States of America
54357	4	2	4	5	This is not really a headline statement, but a description of content.	Noted. The statement is removed.	Sabine Fuss	MCC Berlin	Germany
54359	4	6	4	11	Would be useful to have the potentials numbers as well, maybe in brackets.	Accepted. Content is added in brackets.	Sabine Fuss	MCC Berlin	Germany
10999	4	9	4	9	insert "/" as "…. USD20/tCO2" instead of USD20tCO2-1	Rejected. This is accoriding to IPCC guidelines.	Dong-Woon NOH	Korea Energy Economics Institute	Republic of Korea
16597	4	9	4	9	insert "/" as "…. USD20/tCO2"	Rejected. This is accoriding to IPCC guidelines.	Government of Republic of K	Korea Meteorological Administration (KMA)	Republic of Korea
17799	4	12	4	26	(12 ES) would be good to have the explanations of DACCS and EW at first mention in the first paragraph here, rather than only in the second. They are not familiar except to specialists in the topic.	Accepted. Now spelled out in the above bullet point.	Jonathan Lynn	IPCC	Switzerland
22105	4	12	4	12	suggestion to replace "most scenarios" with "most IAMs scenarios"	Accepted.	Government of France	Ministère de la Transition écologique et solidaire	France
31303	4	12			Having an incorrect unit in the opening paragraph is not a good start!	Editorial errors are corrected. Correctness and consistency of units are observed.	Ralph Sims	Massey University	New Zealand
57687	4	12	4	12	CDR is referred to right at the beginning of the Executive Summary, but is not defined until page 22, line 1. Define terms at first callout.	Rejected. It is defined in the third ES bullet	Government of United State	U.S. Department of State	United States of America
18463	4	14	4	15	Please replace "CDR is also needed to return…" with "IAMs also invoke CDR to return…" For consistency I've made a similar comment in relation page 23 row 34. It is important for readers to understand what is an output of an IAM and what is supported by real-world evidence.	Noted. It is a fact of physics that CDR is needed IF one wants to reduce temperature in the longer term (apart from reductions that might be achieved for a while based on further reductions in short lived climate forcing emissions).	Government of United Kingd	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
22107	4	14	4	16	We suggest to replace "CDR is also needed to return from temporary overshoots of carbon budgets or temperature thresholds by delivering net negative emissions" with "The return from temporary overshoots of carbon budgets or temperature thresholds relies on CDR to deliver net negative emissions"	Partly accepted. Wording changed as noted in response to comment 18463	Government of France	Ministère de la Transition écologique et solidaire	France
54361	4	14			Either delete "some degree of" or "to offset residual emissions", as it is otherwise confusing how residual emissions would be offset other than through CDR.	Accepted.	Sabine Fuss	MCC Berlin	Germany

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
63263	4	16	4	18	It seems a departure from previous IPCC reports to describe BECCS as a technological approach rather than a combined biological-technological approach (especially given that CH. 3 addresses BECCS in the discussion of AFOLU. Furthermore, it would be useful to convey how these different CDR options are currently represented in the illustrative pathways. By grouping BECCS with DACCS and Enhanced Weathering, this implies these forms of CDR are potentially 'substitutable' currently - is this the intent?	Accepted. Enhanced weathering has been dropeed because of the small number of IAM scenarios that have included EW.	Government of Canada	Environment and Climate Change Canada	Canada
22109	4	17	4	17	Suggestion to add after "CDR (BECCS, DACCS, EW)," : "to be developped"	Rejected: Just reporting IAM results in this bullet	Government of France	Ministère de la Transition écologique et solidaire	France
70499	4	17	4	17	the abbreviations are defined only in the next paragraph (line 23) which renders the reading arkward for nonspecialists	Accepted. Now spelled out in the above bullet point.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
18465	4	19	4	22	If these numbers (for Gt potential requirement) are stated, they need to be compared with bottom-up assessments of what is feasible, uncertain as these are. Ch.3 Executive summary says pathways are "plausible representations of the future" and the reader needs to see this demonstrated. As currently presented, there's a danger that the reader might think these numbers are just balancing terms needed to achieve a desired temperature outcome.	Accepted. Reported feasible ranges from the literature are now given in addition to full literature ranges	Government of United Kingd	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
11485	4	23	4	30	The highlighted headline statement of this paragraph tends to convey the message that DACCS, enhanced weathering and ocean-based (mainly ocean fertilisation and ocean alkalinity enhancement) CDR methods are promising techniques to remove carbon from the atmosphere. However, according to the main text, (1) the current scale of DAC plants are designed to capture at most 4 ktCO2yr-1 (P.25, line 27-28) while the order required in mitigation scenarios are GtCO2yr-1 ; (2) enhanced weathering has been demonstrated in the laboratory and in small scale field trials but is yet to be demonstrated at scale (P.27, line 45-46); (3) efficiency of ocean fertilisation depends on the region and experimental conditions and downward carbon transport is less than those observed during natural iron fertilisation (P.30, line 13-15); (4) very few studies have explored the impact of elevated alkalinity on ocean ecosystems (P.30, line 24). It is suggested to revise this paragraph in such a way to avoid painting an overly optimistic and promising picture of CDR technologies.	Accepted: Added - "Despite limited current deployment" and "future potential" to make it clear that this potential cannot currently be realised	SAI MING LEE	Hong Kong Observatory	China
18467	4	23	4	30	I'd prefer to see DACCS treated separately to Enhanced Weathering and ocean-based approaches, as the uncertainties relating to DACCS are very different to the uncertainties relating to EW and ocean-based approaches. We know DACCS can be done in a contained way, ie it does not pose the risks inherent in approaches which distribute materials irreversibly into the environment in the way that EW and many ocean-based approaches would. For this reason, DACCS is much less likely to face the further risks of public unacceptability, and difficulty with MRV. So I suggest the paragraph be modified as Follows: remove enhanced weathering and ocean-based approaches (including ocean alkalinity management and ocean fertilisation) from the bold text and replace "have" with "has". Retain the first sentence of the unemboldened text. Then create a new paragraph starting with this sentence in bold "The potential of EW and ocean-based approaches (including ocean alkalinity management and ocean fertilisation) are much less certain, due to the risks of irreversible environmental impacts and the difficulty of monitoring, reporting and verification. If these risks could be overcome, " then continue with the rest of the paragraph, excpe the last sentence, which isn't necessary.	Rejected: The costs and potentials are comparable, so are report here togther for DACCS, EW and ocean based approaches	Government of United Kingd	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
18469	4	23	4	30	It would be good to include a brief summary of the challenges of, and potential impacts from, deploying ocean fertilisation on the wider marine environment	Taken into account: general consern on OF potential impact on the marine envisronment is added. Details are in 12.3 and table 12.6	Government of United Kingd	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
43755	4	23			Please provide a more comprehensive list of assessed CDR potentials and costs in this paragraph. It is strongly suggested to include BECCS here again, cover afforestation/reforestation separately, same for biochar and agricultural SCS. Suggested marine CDR methods have to also be resolved to cover individual approaches. Marine CDR could also be covered in a separate paragraph so that land and ocean CDR is more easily distinguishable in the ES.	Rejected: This is a chapter 12 executive summary - the CDR potentials for land based options are reported in Ch7. All CDR option costs and potentials are given in the chapter (table 12.6)	Government of Jamaica	Meteorological Service Division	Jamaica
46143	4	24	4	24	We suggest to replace the term "ocean alkalinity management" by "ocean alkalinity enhancement". The former term is not use anywhere else in the report and is less transparent regarding the direction of change.	Accepted. Changed as suggested	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
11001	4	25	4	25	insert the mitigation potential of 4-50GtCO2/year at page 4 considering the figure at Table 12.6	Accepted - but note range is 5-40 not 4-50 - see table 12.6	Dong-Woon NOH	Korea Energy Economics Institute	Republic of Korea
16599	4	25	4	25	insert the mitigation potential of 4-50GtCO2/year at page 4 considering the figure at Table 12.6	Accepted - but note range is 5-40 not 4-50 - see table 12.6	Government of Republic of K	Korea Meteorological Administration (KMA)	Republic of Korea
78779	4	25	4	26	DACCS: the cost range for DACCS is not fully inline with the full body of literature. See the cost results in Breyer et al. (https://www.cell.com/joule/fulltext/S2542-4351(19)30413-1), which would justify to set the lower limit to 50 USD/tCO2.	Noted - cost range updated	Christian Breyer	LUT University	Finland
15657	4	27	4	27	[<1 to ~100] would be changed into [~4 to ~100] or [~4 to 95]	Accepted. Reported feasible ranges from the literature are now given in addition to full literature ranges	Suil Kang	Gwangju Institute of Science and Technology	Republic of Korea
16593	4	27	4	27	[<1 to ~100] would be changed into [~4 to ~100] or [~4 to 95]	Accepted. Reported feasible ranges from the literature are now given in addition to full literature ranges	Government of Republic of K	Korea Meteorological Administration (KMA)	Republic of Korea

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
46145	4	30	4	30	The sentence is trivial: There is uncertainty in almost anything in this report. Please rephrase and specify: e.g. what is the reason and consequence of this uncertainty? We suggest to use a risk framing for the uncertainty to large scale deployment of CDR. The risk is simply that it will not be achieved at the anticipated scale, but reliance on it then will have already hampered other emission reduction efforts.	Accepted. Replaced with a statement about feasibility being uncertain	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
11487	4	31	4	31	The figures "32-36%" are different from what is presented in the main text (25%-42%, P.41, line 21). Please check and revise as appropriate.	**Accepted.** The range was preliminary and corresponds to the range of the SRCCL; it has been aligned with the range given in Chapter 12 for the FDG.	SAI MING LEE	Hong Kong Observatory	China
76353	4	31	4	32	"Food systems currently contribute some [32-36%] to global greenhouse gas (GHG) emissions, while there is still wide-spread food insecurity and malnutrition." seems to suggest that in order to overcome food insecurity and malnutrition, GHG emissions from food systems will have to rise further through increased production - if the intention here is to stress that the current food systems is GHG intensive yet still fails to provide food security or good nutrition, it should be rephrased.	**Accepted.** While the first sentence just states that there are multiple challenges, the following text was modified to make clearer that the GHG intensity of food systems has to be reduced: "Both supply and demand side measures can contribute to [reduce the GHG intensity of food systems], and realising the full mitigation ..." (new text in square brackets)	Gerrit Hansen	Robert Bosch Stiftung	Germany
46147	4	33	4	33	Please indicate the end year of this change, was it from 1990 until 2020?	**Accepted.** Period spelled out.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
30567	4	36	4	41	The sentence says 'Studies show that … a shift to diets with higher share of plant protein could lead to substantial reduction of both GHG emissions and nutrient losses …while providing health benefits and reducing mortality …' It is desirable to show some specific numbers or some explanations to support the idea.	**Partially accepted**. Due to space limitations, only some data on ruminant GHG emissions (beef and dairy) could be included.	Government of Japan	Climate Change Division - Ministry of Foreign Affairs	Japan
46149	4	36	4	41	Since dietary changes towards plant-based diets can reduce demand for agricultural land in high-income countries they also enable low conflict land-based mitigation options such as reforestation and rewetting of peatland. This is another relevant argument for decision makers to include dietary shifts in climate policy and hence should be mentioned here. (see Hayek et al. (2021): The carbon opportunity cost of animal-sourced food production on land. Nature Sustainability. https://doi.org/10.1038/s41893-020-00603-4)	**Accepted.** Text modified to explicitly mention reduced land use associated with a shift towards plant-based diets.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
46151	4	36	4	41	It is of great political relevance and should be mentioned that according to some analyses demand-side management is even essential, e.g. Bajzek, B. et al. (2014): Importance of food-demand management for climate mitigation. Nature Climate Change 4. pp 924-929 (2014) https://doi.org/10.1038/nclimate2353.	**Accepted.** Text modified from 'Both supply and demand side measures can contribute …' to 'Both supply and demand side measures are important ...'	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
22111	4	37	4	37	Suggestion to replace "red meat" with "ruminant meat"	**Accepted.** Text modified accordingly.	Government of France	Ministère de la Transition écologique et solidaire	France
18471	4	42	4	42	Could the authors please clarify what cellular agriculture is? Is this lab grown meat?	**Accepted.** List spelled out to avoid the term 'cellular agriculture' which is a generic term of several technologies. "... cellular fermentation, cultured meat, plant-based alternatives of animal-based food products or controlled environment agriculture promise ... "	Government of United Kingd	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
22113	4	42	4	43	This statement is in contradiction with the analysis in 12.4.3.3, shows similar GHG intensities per unit of protein (mean values ranging 0.3-3.1 kg CO2eq per 100 g of protein), comparable to milk, eggs, and tuna	**Rejected.** As indicated in Section 12.4.3.3, most of the GHG emissions of emerging food production technologies are linked to energy demand. Therefore the statement that these technologies 'promise' substantial reduction is correct, given the caveat in the following sentence that "the full mitigation potential of such technologies can only be realised with low GHG energy systems". Note further that the range is still considerably lower than the GHG intensity ranges for ruminant meat.	Government of France	Ministère de la Transition écologique et solidaire	France
22115	4	43	4	43	Add "production" after direct in this statement, it seems to be missing	**Rejected.** 'Direct GHG emissions' refers to emissions of the food production process itself excluding emissions from energy / material supply. Thus the sentence reads "Emerging food technologies ... promise substantial reduction in direct GHG emissions from food production"	Government of France	Ministère de la Transition écologique et solidaire	France
22117	5	1	5	5	in IAMs models scenarios See p 12-34 l 4, there are important limitations and modelling choices underlying the results that are by no mean an exhaustive assessment of possible strategies	Rejected. The text has been revised but conclusion remains: Modelled pathways limiting warming to 1.5°C commonly involve extensive mitigation in the AFOLU sector that at the same time provides biomass for mitigation in other sectors. We have added line of sight to Ch3 that covers such modelled pathways comprehensively	Government of France	Ministère de la Transition écologique et solidaire	France

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
48069	5	1	5	5	As it has been thoroughly discussed within the context of IPCC SRCCL, the assessment of sustainability impacts of bioenergy systems is complex, and effects may be either positive or negative on different SDGs depending on the context and on the management practices adopted. In addition, as summarized in Chapter 7 , p. 96, l. 17-26, a growing body of literature describes the synergies and positive outcomes when good practices are adopted, highlighting "how the agriculture and forestry sectors can devise management approaches that enable biomass production and use for energy in conjunction with supply of food, construction timber, and other biobased products, reducing the conversion pressure on natural ecosystems." Moreover, as it is highlighted in Chapter 12, Section 12.5, p. 69, l.13-26, IAM's in general are limited in the assessment of the complex dynamics of bioenergy systems as is the case in integrated feed-food-fiber systems: " [...] Because IAMs do not include options of biomass production integrated with existing agricultural and forestry systems, they may over-estimate the total additional land area required for biomass production." Lastly, this SOD apparently is downplaying the potential global expansion of land-based mitigation on abandoned, under-utilized and/or degraded croplands and pastures. The authors are invited to carefully consider the following papers that address the issue, adding up to the growing literature on the issue: Næss, Jan & Cavalett, Otavio & Cherubini, Francesco. (2021). The land–energy–water nexus of global bioenergy potentials from abandoned cropland. Nature Sustainability. 10.1038/s41893-020-00680-5. Kerdan, I.G., Giarola, S., Jalil-Vega, F. et al. Carbon Sequestration Potential from Large-Scale Reforestation and Sugarcane Expansion on Abandoned Agricultural Lands in Brazil. Polytechnica 2, 9–25 (2019). https://doi.org/10.1007/s41050-019-00012-3 Cherubin, M.R.; Carvalho, J.L.N.; Cerri, C.E.P.; Nogueira, L.A.H.; Souza, G.M.; Cantarella, H. Land Use and Management Effects on Sustainable Sugarcane-Derived Bioenergy. Land 2021, 10, 72. https://doi.org/10.3390/land10010072 Therefore, unqualified statements on the negative pressures deriving from bioenergy and BECCS expansions should be revised with caution. The following additional wording should be included as last sentence to the paragraph:	Accepted. The considerations brought forward in this comment was in SOD found in another paragraph. But we have moved it to this paragraph now.	Marcelo moreira	UNICAMP - Agroicone	Brazil
50989	5	1	5	5	As it has been thoroughly discussed within the context of IPCC SRCCL, the assessment of sustainability impacts of bioenergy systems is complex, and effects may be either positive or negative on different SDGs depending on the context and on the management practices adopted. In addition, as summarized in Chapter 7 , p. 96, l. 17-26, a growing body of literature describes the synergies and positive outcomes when good practices are adopted, highlighting "how the agriculture and forestry sectors can devise management approaches that enable biomass production and use for energy in conjunction with supply of food, construction timber, and other biobased products, reducing the conversion pressure on natural ecosystems." Moreover, as it is highlighted in Chapter 12, Section 12.5, p. 69, l.13-26, IAM's in general are limited in the assessment of the complex dynamics of bioenergy systems as is the case in integrated feed-food-fiber systems: " [...] Because IAMs do not include options of biomass production integrated with existing agricultural and forestry systems, they may over-estimate the total additional land area required for biomass production." Lastly, this SOD apparently is downplaying the potential global expansion of land-based mitigation on abandoned, under-utilized and/or degraded croplands and pastures. The authors are invited to carefully consider the following papers that address the issue, adding up to the growing literature on the issue: Næss, Jan & Cavalett, Otavio & Cherubini, Francesco. (2021). The land–energy–water nexus of global bioenergy potentials from abandoned cropland. Nature Sustainability. 10.1038/s41893-020-00680-5. Kerdan, I.G., Giarola, S., Jalil-Vega, F. et al. Carbon Sequestration Potential from Large-Scale Reforestation and Sugarcane Expansion on Abandoned Agricultural Lands in Brazil. Polytechnica 2, 9–25 (2019). https://doi.org/10.1007/s41050-019-00012-3 Cherubin, M.R.; Carvalho, J.L.N.; Cerri, C.E.P.; Nogueira, L.A.H.; Souza, G.M.; Cantarella, H. Land Use and Management Effects on Sustainable Sugarcane-Derived Bioenergy. Land 2021, 10, 72. https://doi.org/10.3390/land10010072 Therefore, unqualified statements on the negative pressures deriving from bioenergy and BECCS expansions should be revised with caution. The following additional wording should be included as last sentence to the paragraph:	Accepted. The considerations brought forward in this comment was in SOD found in another paragraph. But we have moved it to this paragraph now.	Government of Brazil	Ministry of Foreign Affairs of Brazil	Brazil
57689	5	1	5	1	Line 1 begins with the phrase, "Pathways that limit warming ...". Do pathways refer to policy, technological, theoretical scenarios? In this case and later in the document, it is often not clear if a simulation model result is being referenced or if the text is referring to an existing outcome.	Accepted. The text now refers to Modelled pathways and includes line of sight to Ch3 which is the chapter where these are comprehensively discussed	Government of United State	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
80685	5	1	5	3	Pathways using bioenergy and BECCS must account for the carbon deficit of several decades to a century when assessing negative emissions. Danielle Venton, Core Concept: Can bioenergy with carbon capture and storage make an impact?, PNAS (2016); Leturcq, P. (2020) GHG Displacement Factors of Harvested Wood Products: the Myth of Substitution, Nature Scientific Reports 10:1–9; Mary S. Booth, Not carbon neutral: Assessing the net emissions impact of residues burned for bioenergy, Environ. Res. Lett. 13 (21 February 2018); Sterman J. D., et al. (2018) Does replacing coal with wood lower CO2 emissions? Dynamic lifecycle analysis of wood bioenergy, Envtl. Research Letters 13(015007):1–10, 1 ("We simulate substitution of wood for coal in power generation, estimating the parameters governing NPP and other fluxes using data for forests in the eastern US and using published estimates for supply chain emissions. Because combustion and processing efficiencies for wood are less than coal, the immediate impact of substituting wood for coal is an increase in atmospheric CO2 relative to coal. The payback time for this carbon debt ranges from 44–104 years after clear-cut, depending on forest type—assuming the land remains forest. Surprisingly, replanting hardwood forests with fast-growing pine plantations raises the CO2 impact of wood because the equilibrium carbon density of plantations is lower than natural forests. Further, projected growth in wood harvest for bioenergy would increase atmospheric CO2 for at least a century because new carbon debt continuously exceeds NPP. Assuming biofuels are carbon neutral may worsen irreversible impacts of climate change before benefits accrue. Instead, explicit dynamic models should be used to assess the climate impacts of biofuels."). Furthermore, even if BECCS were net zero or negative in the relevant next couple of decades, which it is not, large-scale biodiversity development requires vast land-use changes, which may have significant implications for food security and biodiversity. National Academies of Sciences, Engineering, and Medicine, Negative Emissions Technologies and Reliable Sequestration: A Research Agenda,10 (2019) ("Because food demand is expected to double by mid-century, repurposing a significant amount of current agricultural land to produce feedstocks for BECCS or for afforestation/reforestation might have a significant effect on food availability and food prices, with far-reaching effects on national security and biodiversity."). The IPCC Special Report on Climate Change and Land warns that high implementation of BECCS (11.3 GtCO2 yr-1 in 2050) could increase the population at risk of hunger by up to 150 million people and could have significant impacts on desertification and land degradation.	Noted. The sentences commented upon reflects the assessment of the scientific literature on pathways limiting temperature below 1.5 debrees. The carbon balances associated with biomass and BECCS are also addressed in Ch 3 and Ch7. This comment refers to a selection of a large literature on carbon balances and section 7.4.4 summarizes reasons why studies come to contrasting conclusions. We added line of sight to Ch3 that covers mitigation pathways comprehensively	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America
80829	5	1	5	3	Pathways using bioenergy and BECCS must account for the carbon deficit of several decades to a century when assessing negative emissions. Danielle Venton, Core Concept: Can bioenergy with carbon capture and storage make an impact?, PNAS (2016); Leturcq, P. (2020) GHG Displacement Factors of Harvested Wood Products: the Myth of Substitution, Nature Scientific Reports 10:1–9; Mary S. Booth, Not carbon neutral: Assessing the net emissions impact of residues burned for bioenergy, Environ. Res. Lett. 13 (21 February 2018); Sterman J. D., et al. (2018) Does replacing coal with wood lower CO2 emissions? Dynamic lifecycle analysis of wood bioenergy, Envtl. Research Letters 13(015007):1–10, 1 ("We simulate substitution of wood for coal in power generation, estimating the parameters governing NPP and other fluxes using data for forests in the eastern US and using published estimates for supply chain emissions. Because combustion and processing efficiencies for wood are less than coal, the immediate impact of substituting wood for coal is an increase in atmospheric CO2 relative to coal. The payback time for this carbon debt ranges from 44–104 years after clear-cut, depending on forest type—assuming the land remains forest. Surprisingly, replanting hardwood forests with fast-growing pine plantations raises the CO2 impact of wood because the equilibrium carbon density of plantations is lower than natural forests. Further, projected growth in wood harvest for bioenergy would increase atmospheric CO2 for at least a century because new carbon debt continuously exceeds NPP. Assuming biofuels are carbon neutral may worsen irreversible impacts of climate change before benefits accrue. Instead, explicit dynamic models should be used to assess the climate impacts of biofuels."). Furthermore, even if BECCS were net zero or negative in the relevant next couple of decades, which it is not, large-scale biodiversity development requires vast land-use changes, which may have significant implications for food security and biodiversity. National Academies of Sciences, Engineering, and Medicine, Negative Emissions Technologies and Reliable Sequestration: A Research Agenda,10 (2019) ("Because food demand is expected to double by mid-century, repurposing a significant amount of current agricultural land to produce feedstocks for BECCS or for afforestation/reforestation might have a significant effect on food availability and food prices, with far-reaching effects on national security and biodiversity."). The IPCC Special Report on Climate Change and Land warns that high implementation of BECCS (11.3 GtCO2 yr-1 in 2050) could increase the population at risk of hunger by up to 150 million people and could have significant impacts on desertification and land degradation.	Noted. The sentences commented upon reflects the assessment of the scientific literature on pathways limiting temperature below 1.5 debrees. The carbon balances associated with biomass and BECCS are also addressed in Ch 3 and Ch7. This comment refers to a selection of a large literature on carbon balances and section 7.4.4 summarizes reasons why studies come to contrasting conclusions. We added line of sight to Ch3 that covers mitigation pathways comprehensively	Gabrielle Dreyfus	Institute for Governance & Sustainable Development	United States of America
10811	5	6	5	7	The 1rst sentence is somewhat enigmatic. Also, how is defined the "mitigation value"? This expression is not found in the glossary.	Accepted. Text revised to "Bioenergy is the most land intensive renewable energy option, but the total land occupation of other renewable energy options can become significant in high deployment scenarios". The expression "mitigation value" deleted	Philippe Waldteufel	CNRS	France
18473	5	6	5	7	I'm struggling to understand the first 2 sentences of this paragraph, probably because they're trying to summarise a lot of complex information. Perhaps of the bold text, only this is required "Many mitigation options require land." And perhaps the sentence beginning "The mitigation value..." can be omitted?	Accepted. Text revised to "Bioenergy is the most land intensive renewable energy option, but the total land occupation of other renewable energy options can become significant in high deployment scenarios". The expression "mitigation value" deleted	Government of United Kingd	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
57691	5	6	5	7	Per chapter content, rather than framing issue as "mitigation options require land, although ...", change to read "mitigation options require land management, although ..."	Noted. Text revised to "Appropriate integration of bioenergy and other biobased systems, and of other mitigation options, with existing land and biomass uses can improve resource use efficiency, mitigate pressures on natural ecosystems and support adaptation..."	Government of United State	U.S. Department of State	United States of America
57693	5	14	5	14	Line 14 refers to the sectors in which mitigation measure are categorized. For clarity, the sectors that are referenced in Chapter 12 should be specified.	Taken into account: This text has been deleted as part of other edits to the ES	Government of United State	U.S. Department of State	United States of America
61843	5	14	5	20	"Examples of mitigation measures used in more than one sector include renewable energy technologies, carbon capture, utilisation and storage (CCUS) and fuel cells". This list should include also nuclear energy, our second largest source of low-carbon energy. It is (and can be) used in electricity sector, district heating, seawater desalination, industrial process heat, synthetic fuels and hydrogen production, medical isotope production etc.	Taken into account: This text has been deleted as part of other edits to the ES	Rauli Partanen	Think Atom	Finland
65881	5	14	5	20	"Examples of mitigation measures used in more than one sector include renewable energy technologies, carbon capture, utilisation and storage (CCUS) and fuel cells". This list should include also nuclear energy. It is used in electricity sector, district heating, medical isotope production etc.	Taken into account: This text has been deleted as part of other edits to the ES	Eero Hirvijoki	Aalto University	Finland
5535	5	16	5	16	replace Renewables" by "low carbon sources"	Rejected. Renewables here is an example of low carbon energy. Other examples of low carbon energy are also listed in the statement.	Michel SIMON	Retraité/ Pdt d'association	France
19553	5	16	5	16	Revise as follows: "carbon capture and storage as well as carbon capture and use." Reason: The term CCUS is contested, easily misunderstood, and does not appear to be consistently used throughout the WG3 report.	Accepted; CCUS is no longer used in FGD	Matthias Honegger	Utrecht University, Perspectives climate research, IASS-Potsdam	Germany
60491	5	17	5	17	Please use use CCU and CCS in place of CCUS to be coherent with the rest of the report.	Accepted; CCUS is no longer used in FGD	Célia Sapart	Université Libre de Bruxelles / CO2 Value Europe	Belgium
78827	5	17	5	17	Please use use CCU and CCS in place of CCUS to be coherent with the rest of the report.	Accepted; CCUS is no longer used in FGD	Sylvain Nizou	CEA	France
83735	5	17	5	17	Please use use CCU and CCS in place of CCUS to be coherent with the rest of the report.	Accepted; CCUS is no longer used in FGD	Christian Breyer	LUT University	Finland
57695	5	21	5	21	The sentence beginning on line 21 is unclear. Are authors stating that it's not possible to discern the synergies and trade-offs in either of these contexts?	Taken into account. It is meant that cross-sectoral and not just sectoral integration will be needed to address synergies and trade-offs. Text is revised to improve clarity of the statement.	Government of United State	U.S. Department of State	United States of America
57697	5	21	5	32	Start the paragraph with a more focused conclusion: "Coordinated, cross-sectoral approaches to climate change mitigation should be adopted to target synergies and minimize trade-offs. This requires integrated planning using multiple-objective policy frameworks ..."	Accepted. proposed revision of text adoppted.	Government of United State	U.S. Department of State	United States of America
70501	5	21	5	23	Quite reader unfriendly, could it be rephrased for more clarity?	Accepted. Text revised to make statment clearer.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
27847	5	30	5	31	Delete "Example is the integration between smart agriculture and low carbon energy.", as issues related to reliability, affordability and accessibility are not taken into consideration in this generic example.	Taken into account. sentence deleted.	Eleni Kaditi	Organization of the Petroleum Exporting Countries, OPEC	Austria
79409	5	31	5	31	What is smart agriculture? Are the supposed good practices associated whith "smart" described somewhere in this AR6-WG3 report ? Otherwise, this sentence may conveniently be used by "greenwashers"... to promote unproved or unreliable practices. Overall, there are 22 occurences of "smart", in Chapter 12 ! (See also an undefined smart packaging on top of page 51, and on line 22, page 56.)	Taken into account. Sentence deleted. The usage of "smart" in the chapter is reviewed and considered for change when unclear or confusing.	Raymond Zaharia	Le Club des Argonautes	France
15287	5	33	5	34	Carbon leakage is not caused by the different national climate policies, but probably by the national resource endowment and industrial structure. It is suggested to further verify and modify the statement.	Rejected. The statement is not inconsistent with comment because differences in national climate policies are due to differences in endowments and/or industrial structure.	Government of China	China Meteorological Administration	China
57699	5	33	6	2	This paragraph is too rambling for an Executive Summary. Consider the following formulation instead: "Carbon leakage presents significant potential to undermine benefits under differentiated climate policies. Reducing emissions from transportation for international trade, improved data on emission balances associated with trade, and identifying when and how trade can offer net emission reductions, offer opportunities to mitigate three types of leakage, ..."	Taken into account. statement revised incorporating some of the suggestions in the comment.	Government of United State	U.S. Department of State	United States of America
70503	5	34	5	38	The typology of spillovers could be suppressed; goes too much in detail for an executive summary	Taken into account. statement revised incorporating some of the suggestions in the comment.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
70505	5	42	5	44	This important point needs to be part of the SPM. At present, parts of the SPM imply that emissions would fall worldwide, if only finance, investment, and technology transfer were scaled-up. Yet as these lines point out, this is simply not the case in the absence of movement towards absolute, economy-wide emissions control.	Noted. The observation is suggested to the SPM team.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
70507	5	46	6	2	This point on carbon leakage needs to be stated very carefully. Is there robust evidence that climate action causes emissions to relocate? or only that if emissions were to relocate, the additional transport emissions would be significant? I assume mainly the latter.	Taken into account. statement revised removing ambiguity suggested in the comment.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
70509	6	3	6	14	This paragraph makes a valid point on the need for cross-section considerations. It can also be read in conjunction with the previous paragraph (if an approach is too narrow it may even contribute indirectly to higher emissions). But are there frameworks assessed in the chapter that enable such cross-sectoral thinking? If so, they should be mentioned. If not, consider mentioning it as a knowledge/ expertise gap.	Taken into account. There are no specific examples of sucessful cross-sectoral frameworks used in mitigation financing though the literature suggests that blended private-public financing could be used to leverage cross-sectoral mitigation linkages (see 12.6.4). We added the absence of such examples to the knowelede gap as suggested by the comment.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
70511	6	3	6	43	The three paragraphs also seem long for an executive summary, notably compared to the various synthetic and substantial items of the first page and beginning of the second page of the executive summary	Accepted. The paragraph is revised and shorten taking on board the comment.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
57701	6	9	6	14	Concluding statement is important. See U.S. comments on Section 12.6.4 with suggested references that add to the evidence for the final statement in this paragraph.	Noted.	Government of United State	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
57703	6	15	6	17	This text is repetitive with page 5, lines 21-31. Recommend revising the topic statement and focusing this paragraph to better differentiate it and avoid duplication. A key point here seems to be the need for societies to prioritize among options and the imperative to enable these decisions to be informed by best available information about synergies and trade-offs for each alternative.	Accepted. Statement revised to avoid duplication and to focus more on societal priorties and policy choices.	Government of United State	U.S. Department of State	United States of America
61445	6	15	6	29	Consider adding integrated land use planning and land use managmenet as in important higher level message in designing sectoral and cross-sectoral mitigation policies within a land degradation neutrality framework as mentioned laid out in 12.5.	Accepted. added text in another paragraph in the ES: "The governance of land-based mitigation can draw on lessons from previous experience with regulating biofuels and forest carbon; however, integrating these insights require governance that goes beyond project-level approaches and emphasize integrated land use planning and management approaches.	Graham von Maltitz	UNIVERSITY OF STELLENBOSCH; UNCCD SCIENCE POLICY INTERFACE	South Africa
77637	6	15	6	29	Positing the problem as “the possible implementation of different mitigation options thus depends on how societies prioritise mitigation versus other products and services obtained from land, versus nature conservation and soil/water/biodiversity protection”, enshrines the decision making paradigm that has resulted in short term economic gain being placed above ongoing degradation and loss of ecosystem health and function. The need to change this paradigm has been clear since the Millenium Ecosystem Report 2005 and received a Clarion Call from IPBES in 2019! The deep challenge for us all is to encourage a new paradigm that seeks development pathways that a good for nature, good for people and good for the climate. Only then can we improve the health of the biosphere and ensure we all have a long term and positive future.	Partially accepted. Statement revised taken on board the suggestion in this comment as well as other comments.	Virginia Young	Australian Rainforest Conservation Society	Australia
79411	6	27	6	28	I read : « Other considerations include society’s future dependence on carbon-based energy and materials, [...] » Since such « carbon-based energy and materials, » may involve fossil carbon, non fossil carbon, or both… it may be valuable to address the inaccuracy in this statement (No harm, or much less... for "biom carbon" based energy and materials: they are using non fossil carbon, which has long been present in the multisecular, balanced, carbon cycle.) . See also my comment on "decarbonisation of the building sector", page 23 of the SPM, (as well as lines 40 to 44 on page 35 of Annex B.)	Noted. The referenced statement is beyond the scope of this statement.	Raymond Zaharia	Le Club des Argonautes	France
57705	6	30	6	43	This paragraph should be revised. It understates the importance of reliable monitoring and reporting systems, i.e., stating "Beyond the common task of establishing reliable systems ..." This alone is a huge and critically important international and multi-scale undertaking. Indeed, the potential learnings that are alluded to later, "experience with regulating biofuels and forest carbon" are currently limited by, and controversial because of, the lack of trusted, timely, and comprehensive information on managed landscape conditions.	Accepted. Text revised to avoid giving the impression that the task to establish reliable monitoring and reporting systems is considered to be a trivial task.	Government of United State	U.S. Department of State	United States of America
57707	6	36	6	43	The description and examples of CDR and food systems included here do not help the reader to understand the need for harmonized and equitable systems for monitoring and reporting data in a reliable manner, and the need for policies to be coordinated and complementary, while respecting the subsidiarity principle (which should be mentioned) and respecting the need for policies that are adapted to local social and cultural contexts.	Taken into account. Text revised but important to note that an Executive Summary cannot clarify any single aspect	Government of United State	U.S. Department of State	United States of America
46153	6	41	6	43	Up to now the governance of bioenergy does not ensure that bioenergy has no negative impact on food security. But the phrase written here may create this impression and is therefore misleading. Therefore, the whole sentence should be reduced to: "The governance of land-based mitigation requires governance that goes beyond project-level approaches."	Accepted. We consider it important to state that land-based mitigation can draw on learning from previous experience with regulating biofuels and forest carbon. To address the reviewers' concern for misunderstanding we revised the text to: "The governance of land-based mitigation can draw on lessons from previous experience with regulating biofuels and forest carbon; however, integrating these insights requires governance that goes beyond project-level approaches and emphasize integrated land use planning and management within the frame of the sustainable development goals.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
43239	7	8	7	10	Material and product 9 circularity contributes to mitigation, such as treatment of organic waste to reduce methane emissions, 10 generate renewable energy, and to substitute for synthetic fertilisers. The point about creating a circular loop with organic waste can be further exapnded with the recent research which has highlighted the mitigation benefits of applying compost, including the digestate resulting from anaerobic digestion of organic waste, to soil. The emissions reductions are manifold: avoided methane emissions from the uncontrolled anaerobic decomposition of organic waste; avoided emissions associated with the synthetic fertilizer, peat, and/or pesticides displaced by compost; reduced N2O emissions from reduced use of synthetic fertilizer; reduced emissions associated with tilth and irrigation; and the enhanced uptake of atmospheric carbon by the soil and plants (Favoino & Hogg, 2008; Pezzolla et al., 2012; Qdais et al., 2019; Silver et al., 2018). References: Favoino, E., & Hogg, D. (2008). The potential role of compost in reducing greenhouse gases. Waste Management & Research, 26(1), 61–69. https://doi.org/10.1177/0734242X08088584; Pezzolla, D., Bol, R., Gigliotti, G., Sawamoto, T., López, A. L., Cardenas, L., & Chadwick, D. (2012). Greenhouse gas (GHG) emissions from soils amended with digestate derived from anaerobic treatment of food waste. Rapid Communications in Mass Spectrometry, 26(20), 2422–2430. https://doi.org/10.1002/rcm.6362; Qdais, H. A., Wuensch, C., Dornack, C., & Nassour, A. (2019). The role of solid waste composting in mitigating climate change in Jordan: Waste Management & Research. https://doi.org/10.1177/0734242X19855424; Silver, W. L., Vergara, S. E., & Mayer, A. (2018). Carbon Sequestration and Greenhouse Gas Mitigation Potential of Composting and Soil Amendments on California's Rangelands. In California's Fourth Climate Change Assessment (p. 62). California Natural Resources Agency.	Partially accepted. Waste management contribution to GHGs mitigation is no doubt important. In section 12.6.1 the chapter deals with the cross-sectoral aspects related to material and product circularity (see the box on circular economy). The referenced text in the introduction is revised to reflect waste management as an example of measures that have multiple mitigation impacts. Yet, a complete assessment of waste management contribution to mitigation is the focus of other chapters, e.g. see chapter 8. The provided references will be referred to chapter 8.	Mariel Vilella	Zero Waste Europe/University of Manchester	United Kingdom (of Great Britain and Northern Ireland)
70513	7	12	7	15	Figure 12,1 announced here is in its current state rather unclear and hard to read when considering these lines as a description (see also below).What is needed in this introduction is a table summing up the themes taken in charge in the sectoral chapters and those dealt with in chapter 12, so that we can have from the start a synthetic view of what is dealt with and where it is. It would also be user-friendly when reading the sections of chapter 12 to be able to go back to such a table.	Accepted. Figure replaced by a table taking on board the comment	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
57709	7	25	9	17	Most of this text can be removed. Specific examples are not needed here and should be integrated with the appropriate section of the chapter, rather than in the Introduction.	noted	Government of United State	U.S. Department of State	United States of America
61845	7	34	7	45	The significant cross-sectoral synergies of nuclear energy are not mentioned, yet should be included. They include electricity sector, district heating, seawater desalination, industrial process heat, synthetic fuels and hydrogen production, medical isotope production and co- and tri-generation of hydrogen, electricity and heat. See e.g. UNECE 2021, https://unece.org/sustainable-energy/publications/nuclear-entry-pathways	Taken into account. Synergies of nuclear are now reflected in the text.	Rauli Partanen	Think Atom	Finland
65883	7	34	7	45	The cross-sectorial benefits of nuclear energy should be mentioned Trivially there exist several: electricity, heating, desalination, high-temperature steam for industrial processes, hydrogen production,medical isotopes etc. To avoid technological discrimination, include also nuclear energy in the list that demonstrates cross-sectorial benefits and explain them.	Taken into account. Synergies of nuclear are now reflected in the text.	Eero Hirvijoki	Aalto University	Finland
74245	7	34	7	45	This paragraph should be revised so that it is not renewables centric. Green hydrogen produced by carbon free nuclear is exactly the same as hydrogen produced by renewables. The point is to manufacture hydrogen using carbon free energy. Additionally, due to its energy density, nuclear can produce significantly more hydrogen with a smaller geographical footprint.	Taken into account. Synergies of nuclear are now reflected in the text.	Jeffrey Merrifield	Pillsbury Law Firm	United States of America
57711	7	36	7	36	What is embedded generation? If this refers to such things as rooftop solar, an example stating that would help clarify.	Accepted. Clarification added.	Government of United State	U.S. Department of State	United States of America
5537	7	37	7	37	replace Renewables" by "low carbon sources"	Accepted. renewable replaced with "low carbon"	Michel SIMON	Retraité/ Pdt d'association	France
24697	7	37	7	37	Hydrogen produced via electrolysis: both renewable and nuclear power can be used in this process (see reference already used in the chapter: Bicer, Y., and Dincer, I. (2017). Life cycle assessment of nuclear-based hydrogen and ammonia production options: A comparative evaluation. International Journal of Hydrogen Energy, 42(33), 21559–21570. https://doi.org/https://doi.org/10.1016/j.ijhydene.2017.02.002). So we recommend replacing "Hydrogen and fuel cells, coupled with renewable energy technologies for producing the hydrogen" with "Hydrogen and fuel cells, coupled with low-carbon energy technologies for producing the hydrogen"	Accepted. renewable replaced with "low carbon"	Ann Jessica Johnson	FORATOM (European Atomic Forum)	Belgium
61847	7	37	7	39	"Hydrogen and fuel cells, coupled with renewable energy technologies for producing the hydrogen, is being explored in transport, urban heat, and industry and for balancing electricity supply [..]". Replace the word "renewable" with the word "low-carbon" or add "nuclear energy". See e.g. Graves et al., 2011, https://doi.org/10.1016/j.rser.2010.07.014; Kayfeci et at. 2019, https://doi.org/10.1016/B978-0-12-814853-2.00003-5 and (LucidCatalyst, 2021, https://www.lucidcatalyst.com/hydrogen-report.	Accepted. renewable replaced with "low carbon"	Rauli Partanen	Think Atom	Finland
65885	7	37	7	39	"Hydrogen and fuel cells, coupled with renewable energy technologies for producing the hydrogen, is being explored in transport, urban heat, and industry and for balancing electricity supply [..]". Replace the word "renewable" with the word "low-carbon" or add explicitly the word nuclear. After all, research cited in Chapter 6 promotes hydrogen from nuclear to be cheaper than from solar or wind (Graves et al., 2011, https://doi.org/10.1016/j.rser.2010.07.014 ; Kayfeci et at. 2019, https://doi.org/10.1016/B978-0-12-814853-2.00003-5) and a similar conclusion was made in a more recent report (LucidCatalyst, 2021, https://www.lucidcatalyst.com/hydrogen-report).	Accepted. renewable replaced with "low carbon"	Eero Hirvijoki	Aalto University	Finland

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
80687	7	40	7	42	This assumes bioenergy is carbon neutral, which is not accurate due to the carbon deficit of several decades to a century, and that the supply-chain for CCS is efficient, which is not the case. Danielle Venton, Core Concept: Can bioenergy with carbon capture and storage make an impact?, PNAS (2016); Leturcq, P. (2020) GHG Displacement Factors of Harvested Wood Products: the Myth of Substitution, Nature Scientific Reports 10:1–9; Mary S. Booth, Not carbon neutral: Assessing the net emissions impact of residues burned for bioenergy, Environ. Res. Lett. 13 (21 February 2018); Sterman J. D., et al. (2018) Does replacing coal with wood lower CO2 emissions? Dynamic lifecycle analysis of wood bioenergy, Envtl. Research Letters 13(015007):1–10, 1 ("We simulate substitution of wood for coal in power generation, estimating the parameters governing NPP and other fluxes using data for forests in the eastern US and using published estimates for supply chain emissions. Because combustion and processing efficiencies for wood are less than coal, the immediate impact of substituting wood for coal is an increase in atmospheric CO2 relative to coal. The payback time for this carbon debt ranges from 44–104 years after clear-cut, depending on forest type—assuming the land remains forest. Surprisingly, replanting hardwood forests with fast-growing pine plantations raises the CO2 impact of wood because the equilibrium carbon density of plantations is lower than natural forests. Further, projected growth in wood harvest for bioenergy would increase atmospheric CO2 for at least a century because new carbon debt continuously exceeds NPP. Assuming biofuels are carbon neutral may worsen irreversible impacts of climate change before benefits accrue. Instead, explicit dynamic models should be used to assess the climate impacts of biofuels."). European Academies' Science Advisory Council (2020) Commentary on Forest bioenergy, carbon capture and storage, and carbon dioxide removal: an update, 6 ("A key question raised in our earlier analysis [5] was the degree to which the [carbon dioxide removal (CDR)] assumed in climate scenarios is likely to be achievable in practice. Extensive work has been performed on BECCS, and its overall efficiency in removing CO2 from the atmosphere comprehensively reviewed [30]. The simplistic vision of BECCS (Figure 3A) is that one ton of CO2 captured in the sequestered geologically—which we can regard as a carbon efficiency of 1. However, as with the simplistic concept of carbon neutrality in the bioenergy debate, this is far from the reality. GHG emissions throughout the biomass supply-chain 'leak' carbon, which reduces the carbon efficiency (Figure 3B). Some life cycle analyses [e.g. 31] of the entire process chain for a BECCS	Rejected. The information and material and concerns reflected by the reviewer are valid but irrelevant to the text provided on page 7 lines 40-42.	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America
80831	7	40	7	42	This assumes bioenergy is carbon neutral, which is not accurate due to the carbon deficit of several decades to a century, and that the supply-chain for CCS is efficient, which is not the case. Danielle Venton, Core Concept: Can bioenergy with carbon capture and storage make an impact?, PNAS (2016); Leturcq, P. (2020) GHG Displacement Factors of Harvested Wood Products: the Myth of Substitution, Nature Scientific Reports 10:1–9; Mary S. Booth, Not carbon neutral: Assessing the net emissions impact of residues burned for bioenergy, Environ. Res. Lett. 13 (21 February 2018); Sterman J. D., et al. (2018) Does replacing coal with wood lower CO2 emissions? Dynamic lifecycle analysis of wood bioenergy, Envtl. Research Letters 13(015007):1–10, 1 ("We simulate substitution of wood for coal in power generation, estimating the parameters governing NPP and other fluxes using data for forests in the eastern US and using published estimates for supply chain emissions. Because combustion and processing efficiencies for wood are less than coal, the immediate impact of substituting wood for coal is an increase in atmospheric CO2 relative to coal. The payback time for this carbon debt ranges from 44–104 years after clear-cut, depending on forest type—assuming the land remains forest. Surprisingly, replanting hardwood forests with fast-growing pine plantations raises the CO2 impact of wood because the equilibrium carbon density of plantations is lower than natural forests. Further, projected growth in wood harvest for bioenergy would increase atmospheric CO2 for at least a century because new carbon debt continuously exceeds NPP. Assuming biofuels are carbon neutral may worsen irreversible impacts of climate change before benefits accrue. Instead, explicit dynamic models should be used to assess the climate impacts of biofuels."). European Academies' Science Advisory Council (2020) Commentary on Forest bioenergy, carbon capture and storage, and carbon dioxide removal: an update, 6 ("A key question raised in our earlier analysis [5] was the degree to which the [carbon dioxide removal (CDR)] assumed in climate scenarios is likely to be achievable in practice. Extensive work has been performed on BECCS, and its overall efficiency in removing CO2 from the atmosphere comprehensively reviewed [30]. The simplistic vision of BECCS (Figure 3A) is that one ton of CO2 captured in the sequestered geologically—which we can regard as a carbon efficiency of 1. However, as with the simplistic concept of carbon neutrality in the bioenergy debate, this is far from the reality. GHG emissions throughout the biomass supply-chain 'leak' carbon, which reduces the carbon efficiency (Figure 3B). Some life cycle analyses [e.g. 31] of the entire process chain for a BECCS	Rejected. The information and material and concerns reflected by the reviewer are valid but irrelevant to the text provided on page 7 lines 40-42.	Gabrielle Dreyfus	Institute for Governance & Sustainable Development	United States of America
3543	7	42	7	42	Please, add reference (Hoenig et al 2007): Hoenig, V.; Hoppe, H.; Emberger, B. Carbon Capture Technology—Options and Potentials for the Cement Industry, 1st ed.; European Cement Research Academy (ECRA): Düsseldorf, Germany, 2007; pp. 1–96.	Rejected. Irrelevant as references and citations are not made here but rather in the specific section where CCS is discussed.	Miguel Angel Sanjuán	IECA	Spain
10435	7	42	7	42	Please, add reference (Hoenig et al 2007): Hoenig, V.; Hoppe, H.; Emberger, B. Carbon Capture Technology—Options and Potentials for the Cement Industry, 1st ed.; European Cement Research Academy (ECRA): Düsseldorf, Germany, 2007; pp. 1–96.	Rejected. Irrelevant as references and citations are not made here but rather in the specific section where CCS is discussed.	Aniceto Zaragoza	Oficemen	Spain

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
11591	7	42	7	42	Please, add reference (Hoenig et al 2007): Hoenig, V.; Hoppe, H.; Emberger, B. Carbon Capture Technology—Options and Potentials for the Cement Industry, 1st ed.; European Cement Research Academy (ECRA): Düsseldorf, Germany, 2007; pp. 1–96.	Rejected. Irrelevant as references and citations are not made here but rather in the specific section where CCS is discussed.	PEDRO MORA PERIS	UNIVERSITY	Spain
57713	8	1	8	10	This entire subsection could be summarized in two sentences, covering examples of where mitigation measures result in cross-sectoral interactions and integration, their potential costs and benefits, and relationships with the SDGs reviewed.	noted	Government of United State	U.S. Department of State	United States of America
57715	8	2	8	2	Line 2 refers to mitigation potential, but it is not defined until page 10, line 1.	Rejected. No specific context for the use of "mitigation potentials" is meant but rather the meaning of the general term -- so no need for defining it. Page 10 does not define the term "mitigation potentials" but rather the options and the size and cost of the potentials.	Government of United State	U.S. Department of State	United States of America
18475	8	7	8	8	"green roofs planted to counter urban heat islands reduce the demand for energy for air conditioning and simultaneously sequester carbon". This statement is repeated on p. 93 lines 22-23. Could the authors please specify how big the carbon sequestration effect is and could potentially be? If a benefit is mentioned, such as sequestration from green roofs, please state its size, and provide some context, so the reader can understand whether it's substantial or trivial.	Noted. "green roofs" is mentioned here as an example of synergies and not meant to discuss its magnitude.	Government of United Kingd	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
22119	8	7	8	8	The sentence "Trees and green roofs planted to counter urban heat islands reduce the 8 demand for energy for air conditioning and simultaneously sequester carbon." would need a citation, can reuse 12.6.1.2 (Kim and Coseo 2018; Kuronuma et al. 2018)	Taken into account. "green roofs" is mentioned here as an example of synergies. Reference will be referred to the actual section discussing this.	Government of France	Ministère de la Transition écologique et solidaire	France
61849	8	11	8	14	"Examples include the use of hydrogen as an energy carrier, which, when coupled with renewable energy, [..]". Replace the word "renewable" with the word "low-carbon" or add “and nuclear” after the word “renewable”.	Accepted. Renewables replaced with "low carbon"	Rauli Partanen	Think Atom	Finland
65887	8	11	8	14	"Examples include the use of hydrogen as an energy carrier, which, when coupled with renewable energy, [..]". Replace the word "renewable" with the word "low-carbon".	Accepted. Renewables replaced with "low carbon"	Eero Hirvijoki	Aalto University	Finland
5539	8	13	8	13	replace Renewables" by "low carbon sources"	Accepted. Renewables replaced with "low carbon"	Michel SIMON	Retraité/ Pdt d'association	France
24699	8	13	8	13	With the goal of being technology neutral, we propose changing "when coupled with renewable energy" to "when coupled with low-carbon energy"	Accepted. Renewables replaced with "low carbon"	Ann Jessica Johnson	FORATOM (European Atomic Forum)	Belgium
74247	8	13	8	13	Revise this sentence to strike "renewable" and insert "carbon free" to reflect the role that clean non-reneable generation including nuclear and hydro among others will play in meeting the future demand for fossil free industrial production.	Accepted. Renewables replaced with "low carbon"	Jeffrey Merrifield	Pillsbury Law Firm	United States of America
57717	8	24	9	13	This overview of chapter content is very helpful and well-written.	Noted. Thanks.	Government of United State	U.S. Department of State	United States of
70515	9	4	9	9	This goes too much into detail for an introduction; could be suppressed.	Noted.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
10813	9	12	9	13	"specific emphasis"? "exclusive emphasis" would be more appropriate, as this 12.7 section is not dealing with anything else.	Rejected. Section removed and content merged with other sections.	Philippe Waldteufel	CNRS	France
107	9	14	9	16	Shouldn't Fig. 12.1 reflect links with Health, Biodiversity, and feedback from food production to climate and vice versa?	Rejected. Valid observation but now the figure is replaced with a table based on comments received.	Harry Aiking	Vrije Universiteit, Institute for Environmental Studies	Netherlands
10021	9	14			The quality of ‘Figure 12.1 A schematic of cross-sector perspectives addressed in Chapter 12’ can be improved.	Taken into account. the figure is replaced with a table to improve presentation of the content.	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
29807	9	14	9	16	Figure 12.1 is challenging to understand, and has too much information. Perhaps consider removing the single sector aspect in the schematic to allow more room for the cross-sectoral and system wide perspectives.	Taken into account. the figure is replaced with a table to improve presentation of the content.	Government of Norway	Norwegian Environment Agency	Norway
30569	9	14	9	16	It does not seem that the Figure 12.1 is adequate for 'Schematic of cross-sector perspectives addressed in Chapter 12'. In particular, it seems not clear what 'tourism', 'health' and 'military' mean. (Also the left part of the figure is cut out.)	Accepted. the figure is replaced with a table to improve presentation of the content.	Government of Japan	Climate Change Division - Ministry of Foreign Affairs	Japan
54363	9	14	9	15	This graphic is difficult to read.	Accepted. the figure is replaced with a table to improve presentation of the content.	Sabine Fuss	MCC Berlin	Germany
57719	9	14	9	17	Figure 12.1 needs revision. Besides the boxes being illegible and the text cut off on left margin, there are substantive considerations. Authors might want to generate two separate figures: one to summarize the linkages among sectors in this chapter and other chapters, and a second to use as an example of single vs multi-sector perspectives. The first figure would appear earlier, after it is first called out on page 7.	Accepted. the figure is replaced with a table to improve presentation of the content.	Government of United State	U.S. Department of State	United States of America
70517	9	14	9	17	this table is not readily understandable in its current state. Please give guidelines to be able to read it. Also explicit some abbreviations:EV,RE,,,,	Accepted. the figure is replaced with a table to improve presentation of the content.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
65241	9	15	9	16	figure is low-quality, with undefined acronyms (e.g. RE, EV) and text cropped out on the left	Accepted. the figure is replaced with a table to improve presentation of the content.	Olivier Sulpis	Universiteit Utrecht	Netherlands
54365	9	18	21	1	Assessing sectoral mitigation potentials and putting into perspective with the emissions reductions in the IAM pathways is useful, but the synthesis and - ultimately - relations with chapters 3 and 4 are difficult to understand: Are sectoral mitigation potentials so much higher really only because IAMs do not include all technologies? And what does that imply for decarbonization strategies? Especially since we're looking at 2030, which is in the next 8-9 years.	Noted. The differences between sectoral and IAM estimates are quite modest, as shown in section 12.2.3. This report gives a more detailed view on the short-term mitigation potential, which is useful for policymakers.	Sabine Fuss	MCC Berlin	Germany

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
46155	10	5	10	9	As stated the definition of "technical potential" includes "occasionally" other non-technical constraints, "if these represent strong barriers for the deployment of an option". This definition is quite confusing. Perhaps "theoretical potential" is more fitting. We think that the non-technical barriers to "technical potential" are sufficiently considered in the figures given for various CDR methods in this chapter. Recent literature seems to suggest that environmental, biodiversity-related, social (local livelihoods), institutional and governance constraints are often the main restricting factor for the achievably deployment of CDR (see e.g. Carton, Wim, et al. "Negative emissions and the long history of carbon removal." Wiley Interdisciplinary Reviews: Climate Change 11.6 (2020): e671.; Thoni, Terese, et al. "Deployment of Negative Emissions Technologies at the national level: A need for holistic feasibility assessments." Frontiers in Climate 2 (2020); Low, Sean, and Stefan Schäfer. "Is bio-energy carbon capture and storage (BECCS) feasible? The contested authority of integrated assessment modelling." Energy Research & Social Science 60 (2020): 101326; Brack, Duncan, and Richard King. "Managing Land-based CDR: BECCS, Forests and Carbon Sequestration." Global Policy (2020); and references therein; also REDD+ "lessons learned" literature point in the same direction). If the report is suggesting that a the very high (multi-million km2) land requirement for BECCS or bioenergy in general is compatible with "non-technical" barriers, we feel this conclusion is unduly biased towards IAM results compared to other (e.g. qualitative) methods. Related figures (or these definitions clearly need to be revised) (downward) in view of the non-IAM literature. If all feasibility constraints are not properly considered in a figure about "potential" it is in fact doubtful that such a figure is sufficiently "policy relevant". Please recognize furthermore following literature: Forster, J., et al., 2020, Mapping feasibilities of greenhouse gas removal: key issues, gaps and opening up assessments. Glob. Environ. Change. 63:102073. doi: 10.1016/j.gloenvcha.2020.102073; Considering sustainability thresholds for BECCS in IPCC and biodiversity assessments - Creutzig - - GCB Bioenergy - Wiley Online Library, https://onlinelibrary.wiley.com/doi/10.1111/gcbb.12798; Creutzig, F., Erb, K. H., Haberl, H., Hof, C., Hunsberger, C., & Roe, S. Considering sustainability thresholds for BECCS in IPCC and biodiversity assessments.	Reject. The concrete proposal in to rephrase technical potential to theoretical potential. However, the theoretical potential is much bigger than the technical potential, as it doesn't take the current status of technology into account. As such it is not a very useful concept for policy makers. We acknowledge that there are issues with the technical potential definition as we have here, however, it best reflect the type of data that we are providing. Our approach doesn't present a specific bias towards CDR - this can also be seen in the results, the share in 2030 is very modest.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
10815	10	15	10	16	It is necessary to explain why chapter 8 (settlements) is not considered. Admittedly, the "roadmap" section of chapter 1 hints that this chapter is not really representative of a sector; but then it would be appropriate to indicate here that every mitigation action considered in chapter 8 overlaps actions mentioned in other sector chapters, in such a way that no mitigation action is left aside when not considering chapter 8 here. In other words, the issue about settlements appears as intersectoral; then one wonders why it is localised inside the "sectoral" part of the chapter.	Noted; 'settlements' is not a sector where emissions or potentials can be defined in a simple way, since different sectoral scope and lifecycle assumptions result in almost arbitrary emissions and mitigation potentials. Hence settlements are indeed inter-sectoral and hence do not belong in the assessment of sectoral mitigation potentials."	Philippe Waldteufel	CNRS	France
109	10	37	10	38	COVID is a zoonotic disease, and strongly coupled to animal source food (wet markets, as well as factory farming), which should be made explicit.	Rejected. We do not consider this report as the place to discuss the origins and background of Covid-19, it is just the impact of Covid-19 on developments relevant for GHG emissions.	Harry Aiking	Vrije Universiteit, Institute for Environmental Studies	Netherlands
57721	10	40	10	42	Need clarification of this statement: "For the pre-2020 scenarios variation up to 10% between the different baselines exist." Up to 10% variation in all parameters, or just certain outputs, or both? Can this be translated to a level of uncertainty (i.e., the variability in baselines and underlying assumptions increases uncertainties when making comparisons among different mitigation options)?	Partly accepted. This is about the variability in major variables, like total energy use, total GHG emissions, etc. This will be clarified.	Government of United State	U.S. Department of State	United States of America
79413	11	0	11	0	In table 12.1, the words primary energy & final energy, (AND the third term of the energy cascade: useful energy), should be explained here, (or somewhere else... For instance: in Annex A.) N.B Useful energy = final energy less waste & losses at user level. Despite the rather low level of knowledge of useful energy (e. g. the minimum part of final energy needed to deliver the expected energy service), it is reasonable to assume that useful energy is only 30 to 50 % of primary energy. The potential for revisiting the so-called unavoidable coupling between PIB & primary energy ("CO2 or PIB, one needs to choose !"), is therefore largely under estimated. This is btw obvious when considering the too limited use of co-generation of power and heat ! (It should be made... mandatory !)	Partly accepted. The terms primary energy and final energy are included in the Glossary. The term useful energy is not taken up, as it is not used in the chapter.	Raymond Zaharia	Le Club des Argonautes	France
10023	11	5		10	Reference is made to the table 12.1 Key characteristics of scenarios --- (IEA, 2019; IEA, 2020; IIASA, 2018). Suggestion. Numbers reported in the table should have the same precision level.	Accepted.	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
57723	11	5	11	11	Check Table 12.1 for consistency. There seem to be errors; for example, the values shown for "all scenarios median" omit the SSP2 values, creating a bias for the WEO data. And the Energy related CO2 value for median of scenarios appears high.	Noted - the values have been updated.	Government of United State	U.S. Department of State	United States of America
57725	11	13	11	14	Point readers to another table that identifies (i) which specific mitigation actions this report considers to be mutually exclusive and (ii) which are considered complementary (some of the latter are mentioned in Table 12.6 but it seems a bit random rather than explicit)?	Partly accepted. The discussion on mutually exclusive technologies is taken up in the context of Table 12.3. The overview of "complementary options" is indeed a bit random. It is incomplete and will be removed.	Government of United State	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
48071	12	1	21	0	It is extremely difficult to identify the mitigation potential and costs of biofuels for land transportation in Tables 12.2 and 12.4, particularly their contribution in light vehicle fleet. Biofuels are expressly mentioned only in p.15 (Table 12.2), but indicated costs in the range of 50-100 USD/tCO2 are incompatible with scientific literature. It is also very difficult to identify the sources that were used to reach such a conclusion. In p.12, explanatory text to the table simply states that "For the transport sector, some data from Chapter 10 were used, but they have been complemented by additional sources to achieve a complete overview of emission reduction potentials." (p. 12, l. 6-7). No comprehensive data on the issue was found in Chapter 10, however, regarding mitigation costs with biofuels in light-duty vehicles, while Table 12.2 does not present references to the aforementioned “additional sources” that were used to achieve the presented results with such a high cost for biofuels. As a consequence, the overview of emission reduction potentials and costs is incomplete, and should be revised carefully. In this revision, the authors should include data on negative mitigation costs for bioenergy. The authors are invited to in reassess the issue, taking into account additional literature, as presented below: Grottera et al (2020) “Energy Policy Implications of Carbon Pricing Scenarios of Brazilian NDC implementation” Energy policy (submitted). Carpio, L. G. T., & de Souza, F. S. (2017). Optimal allocation of sugarcane bagasse for producing bioelectricity and second generation ethanol in Brazil: scenarios of cost reductions. Renewable energy, 111, 771-780. T. L. Junqueira et al., “Techno-economic analysis and climate change impacts of sugarcane biorefineries considering different time horizons,” Biotechnol. Biofuels, vol. 10, no. 1, pp. 1–12, 2017, doi: 10.1186/s13068-017-0722-3. Qin, Z., Zhuang, Q., Cai, X., He, Y., Huang, Y., Jiang, D., ... & Wang, M. Q. (2018). Biomass and biofuels in China: Toward bioenergy resource potentials and their impacts on the environment. Renewable and Sustainable Energy Reviews, 82, 2387-2400.	Partly accepted. Based on the literature provided, we have concluded that it is indeed possible to lower costs if next generation biofuels become available. On this basis, the biofuels will be spread over more cost ranges.	Marcelo moreira	UNICAMP - Agroicone	Brazil
46157	12	9	13	9	It will be very important to revise this section with the updated NDCs that will be submitted in the course of 2021 to ensure policy relevance of this report.	Rejected. The NDCs generally provide only a high level target (e.g. total GHG emissions, or GHG intensity) and it is not clear which technologies are included, and what new baselines would be. Therefore, we use a more robust current policies scenario.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
57727	12	16	15	1	In the land-based mitigation options, only afforestation and reforestation are considered along with reducing deforestation. How about forest management? Management would be focused on carbon sequestration and increasing resilience to climate change-induced disturbances/degradation that would mitigate GHG. Better managing current forests should be another policy option.	Accepted. We have included forest management as one of the options.	Government of United State	U.S. Department of State	United States of America
57729	12	16	15	1	Introductory material in this chapter referenced urban trees as a means to reduce energy consumption, but there is no mention of this in the Buildings section of Table 12.2.	Noted. Urban trees can play a role, they can for example be part of "New buildings with high energy performance". But the option as such is too small to include as a separate option in the table.	Government of United State	U.S. Department of State	United States of America
57731	12	16	15	1	Under the Industry category, it was surprising to see Bioenergy as one of the highest cost categories. Given the collapse in the low grade market in the U.S., manufacturers are giving away chips. The cost of these equivalents is highly nation-specific so this cost estimate is misleading for policy implementation. A connection between reducing forest degradation (improving forest health) and the subsequent cost/availability of low grade material for bioenergy is not made.	Rejected. Low chips prices can be considered as a temporary issues. If the demand for bio-energy would really become substantial, then prices will certainly rise.	Government of United State	U.S. Department of State	United States of America
57733	12	16	16	1	In Table 12.2, estimates are taken from the literature; so, if there are no studies, there is no potential. Obviously, this does not mean there is no potential mitigation in these sectors, just that there is no basis in existing studies to assess what it might be. The title should be revised accordingly.	Accepted. We will indicate this.	Government of United State	U.S. Department of State	United States of America
70519	12	38	12	38	What is in substance the difference between"business as usual", "current", and"Stated" policies. See also table 12.1	Noted. We do not use the term business-as-usual. The present state of policy implementation is described by so-called current-policy scenarios. That is the only term we use. Next to that, the IEA uses in it last World Energy Outlook the term Stated Policies, so we had to use that. The complications are explained in a footnote to Table 12.1.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
8147	13	1	15	1	Table 12.2, "Land-based mitigation … " (page 13): Please change the order to "afforestation, reforestation, reducing deforestation". The text as it is now could be misunderstood as e.g. "reducing reforestation".	Taken into account. The category will be split in two, which avoids the problem.	Joachim Rock	Thuenen-Institute of Forest Ecosystems	Germany
8149	13	1	15	1	Table 12.2, "Land-based mitigation … " (page 13): Please delete "s change" from "other land-uses change options", since the framework you refer to is called "other land use" and should not be confused with "LULUCF". Besides, the options mentioned (fire prevention, peatland restoration) do not require land-use change.	Taken into account. The categories will be re-ordered, making the error disappear.	Joachim Rock	Thuenen-Institute of Forest Ecosystems	Germany
9027	13	1	13	1	table12-2- it suggested that nuclear energy considered as a manner if decreasing greenhouse gases decreasing.	Noted. Nuclear energy is considered as one of the options for GHG mitigation in Table 12.2	Behzad Layeghi	IRIMO	Iran

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
15827	13	1	16	19	Table 12.2 "Detailed overview of net GHG emission reduction potentials (GtCO2-eq) in the various cost categories." This table is considered important as it is mentioned in the Technical Summary (TS.7 pages 101-103). But this table is deeply misleading and its interpretation doesn't follow the recommendation stated by the report ("As suggested previously, the overview presented in Table 12.2 should be interpreted with care, as the implementation of one option may affect the mitigation potential of another option"). Technically speaking, the table may have some economic truth if it were interpreted in an economic marginal way, that is marginal abatement costs for small volumes (not Gigatons of CO2), at the margin of assumed energy mixes (close to real existing mixes in 2030, more built-in from modelling in 2050). But its interpretation in a systemic and global way for 2030 conveys a major misleading idea. [Continued below]	Responce in the cells below.	Jean-Michel Trochet	EDF group (French Utility)	France
15829	13	1	16	19	(1) low unit cost abatements of solar PV and wind associated with volumes in Gigatons of CO2 are underestimated as they miss (a) their impact of their local decreasing economic value with their share in electricity mixes (particularly true for solar PV), (b) their impact on the cost of economically premature retirement of thermal plants, both emitting ones (coal and gas plants) and non-emitting ones (nuclear and hydro), (c) their impact on electricity grid reinforcements. (2) Concerning nuclear and hydro power, the economic value and low associated volumes miss the issue of extending or not the lifetime of existing plants. [continued below]	Partly accepted. The systemic impacts of solar and wind energy are recognized and discussed in Chapter 6. It is now widely accepted that large volumes of intermittent renewables can be integrated into electricity systems without problems. In the longer term (beyond 2030) there will certainly be higher grid integration costs. Regarding life-time extension of existing plants, for nuclear this is now touched upon in Supplementary Material 12.A. There it is shown that life-time extension of nuclear plants is at best part of the total nuclear potential. Lifetime extension of hydropower plants is to our knowledge not a critical mitigation option.	Jean-Michel Trochet	EDF group (French Utility)	France
15831	13	1	16	19	(3) Concerning buildings, there is not much doubt on low unit abatement costs in new buildings for insulation, HVAC systems, water heating and other options to reduce thermal energy use. But for existing buildings, literature is much more cautious. Actually, in a case by case analysis, one might find examples of buildings renovation with low abatement cost). But analyses on a wider scale show that abatement costs dramatically increase to levels above USD 500 or 1000 tCO2equ-1 (For an illustration in the USA, see Allcott, Greenstone 2012, "Is there un efficiency gap?" Journal of Economic Perspectives vol 26 n°1, and in France, see Blaise, G., & Glachant, M. (2019, sept-oct). "Quel est l'impact des travaux de rénovation énergétique des logements sur la consommation d'énergie ? Une évaluation ex post sur données de panel". (C. F. l'Energie, Éd.) Revue de l'Energie. https://www.larevuedelenergie.com. ([continued below]	Noted. We recognize that mitigation costs for existing buildings are much higher than those of new buildings. The balance of literature gives a range of 20 -200 USD/tCO2e, which we have now implemented in the table (higher than in the SOD). The values quoted in the comments are considered as extremes.	Jean-Michel Trochet	EDF group (French Utility)	France
15833	13	1	16	19	At last but not least, for the reasons mentioned above, my guess would be that Table 12.2 may not be consistent with the results provided by IAM used in the whole WG3 report. It's only a guess, as I haven't access to the new database of IAM models.	Noted. A comparison is done in Section 12.3, showing that are differences for some sectors (notably industry), but overall there is a reasonable match between the two approaches.	Jean-Michel Trochet	EDF group (French Utility)	France
29043	13	1	15	1	I have commented on this table in the Technical Summary, too. It is mentioned that the potentials presented for the energy sector are indicative and placeholders, this is somewhat concerning, information presented in the Technical Summary should be more reliable. The range given for 'Bioenergy with CCS' under AFOLU sector also seems different from the Summary for Policymakers, which also gave median 0.8 GtCO2/a but for a range of 0-6 and didn't mention an additional technical potential of 4 Gt but rather some additional mitigation of up to 7 Gt across bioenergy in general from substitution. Does 'Biofuels' include biofuels with CCS, such as corn-based ethanol with CCS? This can be delivered at costs below $50/tCO2 (McLaren, D., 2012. A comparative global assessment of potential negative emissions technologies. Process Safety Environ. Protect. 90, 489–500.) The note on DACCS is important and needs to be highlighted/mentioned in other parts in the summaries or chapters that discuss DACCS and cite large technical potentials.	Taken into account. The numbers for the energy sector will be finalized, and show some changes compared to the numbers in the SOD. Biofuels with CCS is not covered in the assessment. It is interesting, but probably relatively small. Note that this is all for 2030 and potentials beyond 2030 maybe substantially bigger, including for DACCS.	Jasmin Kemper	IEAGHG	United Kingdom (of Great Britain and Northern Ireland)
29809	13	1	15	2	In figure 12.2 would it be possible to indicate to what degree the different estimates include socio-economic benefits (co-benefits) such as reduced air pollution in the calculation.	Noted. Only monetary costs and benefits are included. This is now also repeated in the caption of Table 12.2 (Table 12.3 in the final version)	Government of Norway	Norwegian Environment Agency	Norway

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
50991	13	1	21	0	It is extremely difficult to identify the mitigation potential and costs of biofuels for land transportation in Tables 12.2 and 12.4, particularly their contribution in light vehicle fleet. Biofuels are expressly mentioned only in p.15 (Table 12.2), but indicated costs in the range of 50-100 USD/tCO2 are incompatible with scientific literature. It is also very difficult to identify the sources that were used to reach such a conclusion. In p.12, explanatory text to the table simply states that "For the transport sector, some data from Chapter 10 were used, but they have been complemented by additional sources to achieve a complete overview of emission reduction potentials." (p. 12, l. 6-7). No comprehensive data on the issue was found in Chapter 10, however, regarding mitigation costs with biofuels in light-duty vehicles, while Table 12.2 does not present references to the aforementioned “additional sources” that were used to achieve the presented results with such a high cost for biofuels. As a consequence, the overview of emission reduction potentials and costs is incomplete, and should be revised carefully. In this revision, the authors should include data on negative mitigation costs for bioenergy. The authors are invited to in reassess the issue, taking into account additional literature, as presented below: Grottera et al (2020) “Energy Policy Implications of Carbon Pricing Scenarios of Brazilian NDC implementation” Energy policy (submitted). Carpio, L. G. T., & de Souza, F. S. (2017). Optimal allocation of sugarcane bagasse for producing bioelectricity and second generation ethanol in Brazil: scenarios of cost reductions. Renewable energy, 111, 771-780. T. L. Junqueira et al., “Techno-economic analysis and climate change impacts of sugarcane biorefineries considering different time horizons,” Biotechnol. Biofuels, vol. 10, no. 1, pp. 1–12, 2017, doi: 10.1186/s13068-017-0722-3. Qin, Z., Zhuang, Q., Cai, X., He, Y., Huang, Y., Jiang, D., ... & Wang, M. Q. (2018). Biomass and biofuels in China: Toward bioenergy resource potentials and their impacts on the environment. Renewable and Sustainable Energy Reviews, 82, 2387-2400.	Partly accepted. Based on the literature provided, we have concluded that it is indeed possible to lower costs if next generation biofuels become available. On this basis, the biofuels will be spread over more cost ranges.	Government of Brazil	Ministry of Foreign Affairs of Brazil	Brazil
51189	13	1	13	1	"Table 12.2 Detailed overview of net GHG emission reduction potentials (GtCO2-eq) in the various cost categories". The title of the table should precise that this is the reduction potential "by 2030"	Accepted. The title now says "for 2030, to indicate that it is for one year.	Eric PROUST	European Nuclear Society (ENS)	France
51191	13	1	13	1	"Table 12.2 Detailed overview of net GHG emission reduction potentials (GtCO2-eq) in the various cost categories". The dispatching by cost categories of the reduction potential appear to come out of a hat without any explanation (right, it is said cost levels were newly analysed by the authors of Chapter 6, but this is a bit short). Some justification is needed	Accepted. A more transparent explanation will be provided.	Eric PROUST	European Nuclear Society (ENS)	France
57735	13	1	13	1	The caption for Table 12.2 notes values "reflect full range". Citations used to create these ranges would be helpful.	Noted. The citations were not complete in the SOD, especially for the power sector. The citations will mostly provided by the sectoral chapters, and if not in Supplementary 12.A.	Government of United State	U.S. Department of State	United States of America
57737	13	1	13	5	Table 12.2, first cost column, shows costs less than zero. While some items, such as reducing use of something, could have negative cost, these should be explained in notes. Specifically, add a note to explain how wind energy can be installed for costs less than zero.	Accepted. This will be explained in the caption of Table 12.2 (Table 12.3 in the final version).	Government of United State	U.S. Department of State	United States of America
57739	13	1	13	5	Table 12.2 includes a single row for "Reducing deforestation, Reforestation and afforestation." Separate out forest conservation, management, and reduced deforestation from reforestation. These are completely different costs, and the risks and potentials have been studied separately. The societal net benefits of conservation need to be considered and emphasized in this chapter on cross-sectoral synergies, rather than obscured as now presented in this table.	Accepted. The categories will be split.	Government of United State	U.S. Department of State	United States of America
61851	13	1	13	1	Table 12.2, explain how wind energy can have negative costs in reducing greenhouse gases, if all other technologies have positive costs, especially as we know that wind integration (system) costs increase exponentially as its share increases (See OECD-NEA 2019. http://www.oecd-nea.org/ndd/webinars/2019/system-costs/.) Further, research shows that integrating nuclear reactors into district heating networks could have negative costs (cheaper than current production). See Lindroos et al, 2019, https://doi.org/10.1080/15567249.2019.1595223, Värri et al, 2019, https://doi.org/10.3390/en12112195 and Teräsvirta et al, 2020, https://doi.org/10.3390/en13153782.	Noted. The systemic impacts of solar and wind energy are recognized and discussed in Chapter 6. It is now widely accepted that large volumes of intermittent renewables can be integrated into electricity systems without problems. In the longer term (beyond 2030) there will certainly be higher grid integration costs. The cost ranges for nuclear are based on the balance of evidence. Note that this is all for 2030.	Rauli Partanen	Think Atom	Finland
65889	13	1	13	1	Table 12.2, explain how wind energy can have negative costs in reducing greenhouse gases, if all other technologies have positive costs. What makes wind special in this perspective?	Noted. Costs of wind energy have come down substantially and electricity production costs are now often lower than their fossil alternative (meaning mitigation costs are negative). In the final draft this will also be the case for solar energy.	Eero Hirvijoki	Aalto University	Finland
70521	13	1	15	1	The ocean based CDR and blue carbon are missing from the Table 12.2.	Noted. Just as for DACCS and enhanced weathering, this is an option that will not contribute discernibly by 2030.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
70523	13	1	16	1	Table12,3, this table needs some effort to read. If I understand correctly, for land-based mitigation we have a best estimate and a range, while for the energy sector we have a range but no best estimate. Also in the energy sector, the figures in two next columns are the same; e.g. 0.43 for bio energy; I suppose they add to give a potential of 0 .86. some explanations would be welcome.	Partly accepted. The sectoral chapters have taken different approaches in estimating emission mitigation potentials. In the final table we will make clearer that in many cases the distribution over the cost ranges is not precisely known (this was the reason to distribute the bio-energy potential 50/50 over the cost ranges).	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
77147	13	1	15	30	The tables greatly under-estimate mitigation costs, as detailed in comment #3.	Rejected. We could not find what is comment #3 is related to. The costs are based on the best assessment of the available literature.	Jim O'Brien	Expert Reviewer AR6 SOD WG1	Ireland

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
78781	13	1	13	1	cost for GHG emission reduction of PV is for sure wrong. This is rather in the category of <0 and higher. Bogdanov et al. (https://www.nature.com/articles/s41467-019-08855-1) found a substantial potential to reduce power system cost compared to the present, mainly driven by solar PV - that's completely missing. Even worse, results based on IAMs are massively biased against solar PV as clearly documented by Jaxa-Rozen (https://www.nature.com/articles/s41558-021-00998-8) compared to non-IAM scenarios. A major revision of this item has to be carried out for a proper assessment of the potential of solar energy. The GHG reduction potential by solar energy is MUCH higher and for less cost. See also the scenario results of Ram et al. (http://energywatchgroup.org/wp-content/uploads/EWG_LUT_100RE_All_Sectors_Global_Report_2019.pdf ; scenario in AR6 scenario database), which finds high benefits for a stongly solar energy based energy system across sectors.	Partly accepted. In the re-analysis, we have recognized that there is a large potential for PV with net negative costs. Note, however, that this Table is not based on the use of IAMs.	Christian Breyer	LUT University	Finland
18477	13	7	13	7	Please add in 2030 before the brackets, otherwise the reader may not understand this impotant point.	Accepted.	Government of United Kingd	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
82649	13		13		table 12.2 - could seriously mislead policy makers about the potentials of different technologies in the energy sector (at least) to reduce GHG emissions. There are several problems with it: The emissions reduction potentials are based on a UNEP 2017 report. However, this report was not consistent in how it treated different energy technologies. For wind and solar it states how they could potentially grow but for others it merely calculates their growth based on the difference of the IEA 450 scenario compared to the current policies scenario. I don't believe that this 450 scenario appears in the models presented in this report – so why is it used as the basis of GHG reduction potentials? It would be more natural to use the scenarios presented in this report for the ranges of emission reduction potential for different technologies Technology development has not stayed static since the UNEP 2017 report – or the earlier IEA models it is largely based on. For nuclear energy in particular, a whole new class of technologies is approaching commercialisation which offers an option for decarbonizing certain heat applications and hydrogen in addition to just electricity. Nuclear energy's potential has grown, but this will not be reflected here because of the methodology used. Wind and solar may be cheap on an LCOE basis, but as energy scholars well know, the limitations to their deployment will largely come down to additional grid system and integration costs. The cost categories in this table do nothing to capture that and instead seem to suggest they should be prioritsied above other solutions. Another notable development is in nuclear long-term operation, with nuclear plants now being licensed for as long as 80 years - twic as long as originally envisaged 40 year lifespans. Nuclear LTO is among the cheapest of all generation options as noted in IEA Nuclear Power in a Clean Energy System. This is also not reflected in the cost category data. To summarise – the methodology used in the table is problematic, some of the data is old and the	Noted. In 2017, the IEA 450 scenario was one of the few that determined an expansion scenario for nuclear energy (note that the IEA is less optimistic in recent WEOs). The literature review has not shown new material. The systemic impacts of solar and wind energy are recognized and discussed in Chapter 6. It is now widely accepted that large volumes of intermittent renewables can be integrated into electricity systems without problems. In the longer term (beyond 2030) there will certainly be higher grid integration costs.	Jonathan Cobb	World Nuclear Association	United Kingdom (of Great Britain and Northern Ireland)
7707	13				It suggested that nuclear energy considered as a manner if decreasing greenhouse gases decreasing.	Noted. Nuclear energy is considered as one of the options for GHG mitigation in Table 12.2 (Table 12.3 in the final version).	Leila Rashidian	Meteorological	Iran
48547	13				Nuclear has large technical potential which is not shown here to reduce GHG emissions. Assumptions pertaining to cost are likely limiting the reflection of nuclear's broader potential. It is unclear if small modular reactors are factored and would be good to spell out in a note within the table.	Noted. If there is larger potential that is so far not reflected in the literature. Small modular reactors are not expected to play a big role already in 2030.	Kathleen Araujo	CAES Eenrgy Policy Institute/Boise State University	United States of America
52571	13		15		This is a very good table however it should include cost of infrastructure and deployment.	Noted. Costs of infrastructure is included. Also costs of installation is included in the cost estimates.	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
43361	14	1	15	1	The table 12.2 is quite confusing. I believe that if the person did not read the previous chapter it can get quite tricky to comprehend. I personally had difficulty to understand it.	Noted. We have at least expanded the caption to make it clearer.	BEATRIZ BECCARI BARRETO	Politecnico di Milano	Brazil
57741	14	1	14	2	In Table 12.2, top row, the note for "Bioenergy with CCS" needs revision and clarification. The note should be mirrored in the land-based mitigations entry in Table 12.6 (or where appropriate to sum to total potential). How much is total BECCS potential and what share is shown here vs under land-based?	Partly accepted. The potentials in Land based .. On the one hand and in the Energy sector and Industry on the other hand are about the same option. This will be clarified.	Government of United State	U.S. Department of State	United States of America
57743	14	1	14	2	Under Buildings, it's not clear how investments in PV systems or building bioenergy has costs less than zero. Add notes to explain and or cross-reference the proper section. Need to explain "sufficiency options" for buildings. Is that meant to refer to "net-zero" emission buildings? Self-sufficient, off-grid buildings (which are different than net-zero)? Or something else?	Partly accepted. The costs have been re-analysed by Chapter 9 colleagues, and now the negative costs have disappeared. Sufficiency options is now renamed "Avoid demand for energy services" and includes options like floor space rationalisation.	Government of United State	U.S. Department of State	United States of America
22121	14		14		Table 12.2 : In the line "Increased use of wood products (e.g. in construction)" The corresponding term in chapter 7 is "enhanced use", which is more appropriate. Indeed, the is strong evidence that increased use would result in higher emissions, at least until 2050. The wording should therefore be changed to "Enhanced use of wood products (eg. shift from short-lived uses such as paperboard to long-lived uses such as construction).	Accepted, wording is changed.	Government of France	Ministère de la Transition écologique et solidaire	France

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
11007	16	15	16	15	baseline emissions of 58-66 GtCO2 instead of 57-65 GtCO2 based on Table 12.2, 62.1(57.8-66.3)	Noted. Thanks for pointing to this inconsistency. Numbers will slightly change, but all will be adapted to the latest version.	Dong-Woon NOH	Korea Energy Economics Institute	Republic of Korea
16605	16	15	16	15	baseline emissions of 58-66 GtCO2 instead of 57-65 GtCO2 based on Table 12.2, 62.1(57.8-66.3)	Noted. Thanks for pointing to this inconsistency. Numbers will slightly change, but all will be adapted to the latest version.	Government of Republic of K	Korea Meteorological Administration (KMA)	Republic of Korea
8153	16	26	17	4	Table 12.3: Please delete "change" from "Forestry and other land-use change". You do not want to mix the concepts of (A)FOLU and LULUCF.	Accepted.	Joachim Rock	Thuenen-Institute of Forest Ecosystems	Germany
18479	16	26	16	26	There don't seem to be any units in either the table itself or the caption, and please can you add in 2030, as for Table 12.2, if that is what's meant?	Accepted. Apology for the omissions.	Government of United Kingd	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
29811	16	26	17	1	Figure 12.3 - please include the unit of measure.	Accepted.	Government of Norway	Norwegian Environment Agency	Norway
51193	16	26	16	28	"Table 12.3 Overview of aggregate sectoral net GHG emission reduction potentials": add "by 2030" ("emission reduction potentials by 2030")	Accepted.	Eric PROUST	European Nuclear Society (ENS)	France
57745	16	26	17	4	In Table 12.3, column 5 presents findings from AR4. Why are results from AR5 omitted? The literature assessed is from AR5 to now. The text should explain why AR4 is the chosen point of comparison.	Taken into account. AR5 did not report potentials in this form. Rather, the outcomes of the sectoral chapters were presented as relative potentials (per kWh, vehicle-km, etc.). This is now explicitly reported in the tekst right after Table 12.3 (future Table 12.4)	Government of United State	U.S. Department of State	United States of America
43363	16	28	17	4	I believe the table 12.3 does not have the unit. I did not see it, just saw the cost per ton of CO2eq.	Accepted, unit is added.	BEATRIZ BECCARI BARRETO	Politecnico di Milano	Brazil
10025	16		17		Reference is made to the table 12.3 Overview of aggregate sectoral net GHG emission --- the three different estimates. Suggestion. Numbers reported in the table should have the same precision level.	Partly accepted. An exception is made for "Total of all sectors" numbers, for which a precision of 0.1 GtCO2 would suggest unjustified precision.	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
27849	16		17		Table 12.3 to clarify whether the presented figures are for 2030 or another year/time period.	Accepted.	Eleni Kaditi	Organization of the Petroleum Exporting Countries, OPEC	Austria
57747	17	6	17	10	So AR5 did not present costs and potentials?	Taken into account. AR5 indeed did not report potentials in this form, rather relative potentials (per kWh, vehicle-km, etc.). This is now explicitly reported in the tekst right after Table 12.3.	Government of United State	U.S. Department of State	United States of America
70525	17	6	17	10	AR4 used as source. How about AR5?	Taken into account. AR5 indeed did not report potentials in this form, rather relative potentials (per kWh, vehicle-km, etc.). This is now explicitly reported in the tekst right after Table 12.3.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
57749	17	15	17	21	Should add a paragraph or table indicating how many studies are in the various categories shown in Tables 12.2 and 12.3.	Partly accepted. An overview of the number of studies used per sector will be added in the text of the chapter.	Government of United State	U.S. Department of State	United States of America
57751	17	15	17	21	Additional discussion should highlight what the big points are. At present, the text merely indicates nothing other than IAMs tend to show more potential in some sectors, sectoral models show more potential in others, and there is overlap between the two types of model results in most sectors. So what do Figures 12.2 and 12.3 tell or show us then?	Partly accepted. The figures tell as that there is a fair agreement (with exceptions) between IAM and sectoral approaches. This will be elaborated as far as possible.	Government of United State	U.S. Department of State	United States of America
43365	18	1	18	8	Figure 12.2 could be bigger and better quality. I was quite interested in more details but could not really see it properly. Thank you.	Noted - the figure has been updated.	BEATRIZ BECCARI BARRETO	Politecnico di Milano	Brazil
31305	18	2			No gases shown for Agriculture and AFOLU. If these are "All gases" need to say so. Also change "transportation" to "transport" here and elsewhere - as used in rest of report.	Accepted - the figure caption, etc., has been corrected.	Ralph Sims	Massey University	New Zealand
51195	18	13	18	14	"Both the sectoral analysis and the IAMs find a dominant role for solar and wind energy, complemented with growth in a range of other technologies": what Fig. 12.3. shows to me is that no energy is "dominant". In particular, the role of hydro appears comparable to the one of wind.	Accepted. The role of hydropower and nuclear remains important. We just wanted to say that in terms of growth potential solar and wind are most important. We have rephrased the sentence.	Eric PROUST	European Nuclear Society (ENS)	France
57753	18	17	18	17	The text says that demand-side options are represented to a limited extent in IAMs; however, there are many studies that explore the role of demand-side drivers in mitigating emissions, and the SSPs are explicitly designed to include representation of different demand-side drivers beyond population and GDP.	Noted. This is certainly true. But making demand-side drivers a lever for mitigation (like dietary changes and rationalisation of floor space) is still relative rare in IAMs.	Government of United State	U.S. Department of State	United States of America
70527	19	1	19	2	figure 12.3. The colours are inverted compared to figure 12.2; they are also opposite to those stated in the figure legend;	Accepted - the figure has been corrected.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
65891	19	2	19	6	Figure 12.3. The color labels (IAM, sectoral) do not match the explanation in the figure caption. Provide a fix.	Accepted - the figure has been corrected.	Eero Hirvijoki	Aalto University	Finland
12043	19	5	21	1	Removals potential for buildings through biomass inclusion may be =1GtCO2e by 2050. The capacity for buildings to store carbon could then be included in the 'Degree to which zero-GHG is possible' column (see p46-28 in Greenhouse Gas Removal 2018 London: Royal Society and Royal Academy of Engineering https://royalsociety.org/topics-policy/projects/greenhouse-gas-removal/?gclid=EAIaIQobChMIh62ZzrmU7wIVEu7tCh1lfgLAEAAYASAAEgKCyfD_BwE and . McLaren D. A comparative global assessment of potential negative emissions technologies. Process Safety and Environmental Protection. 2012 Nov;90(6):489–500. Available from: http://dx.doi.org/10.1016/j.psep.2012.10.005	Partly accepted. Brief text is added.	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
12459	19	10	19	12	Add as example: measures to reduce methane emissions from harder to mitigate sources, including removal from elevated-methane ambient air near emission sources. See: Nisbet et al, "Methane Mitigation: Methods to Reduce Emissions, on the Path to the Paris Agreement", https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019RG000675	Noted. This is a very interesting paper, and the idea of capturing methane near sources is challenging. However, it doesn't provide concrete numbers for emission mitigation in 2030.	Maarten Van Herpen	Acacia Impact Innovation BV	Netherlands
70529	19	10	19	10	table 12.1 does not refer to technologies	Accepted. We referred to the wrong table, should be 12.2 (final version 12.3).	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
111	20	1	20	1	To Complementary options of Agriculture may be added Precision agriculture, which in fact reduces costs.	Noted. Precision agriculture will help to realize the potential in that sector, but not big enough to be mentioned as a separate option.	Harry Aiking	Vrije Universiteit, Institute for Environmental Studies	Netherlands

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
12461	20	1	20	1	Under agriculture - 'complementary options', add in the box: methane oxidation/removal from elevated-methane ambient air near agriculture sources. See same source as comment above. Regarding the degree to which zero-GHG is possible, the use of methane oxidation from ambient air could make these operations zero-methane or even below zero methane (if the oxidation solution oxidizes more than they emit). See: Nisbet et al, "Methane Mitigation: Methods to Reduce Emissions, on the Path to the Paris Agreement", https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019RG000675.	Noted. This is a very interesting paper, and the idea of capturing methane near sources is challenging. However, it doesn't provide concrete numbers for emission mitigation in 2030.	Maarten Van Herpen	Acacia Impact Innovation BV	Netherlands
51197	20	1	20	1	In Table 12.4/energy sector, reference made to sections of chapter 6 are erroneous. Update needed.	Noted. References will be removed.	Eric PROUST	European Nuclear Society (ENS)	France
51199	20	1	20	1	Table 12.4/specific costs: projecting specific costs 30 years ahead is pretty adventurous. Theses projections look pretty optimistic. One wonders what can be the degree of uncertainty associated with theses indications.	Noted. Intermediate costs means costs up to USD 100/tCO2, which is not only optimistic.	Eric PROUST	European Nuclear Society (ENS)	France
57755	20	1	20	1	In Table 12.4, the row for Transport is blank.	Noted. If table will stay in, the row will be filled.	Government of United State	U.S. Department of State	United States of
70531	20	1	20	1	table 12.4. Information concerning the transport sector missing	Noted. If table will stay in, the row will be filled.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
22123	20		20		Table 12.4 : The elements for the line concerning transports seem to be missing	Noted. If table will stay in, the row will be filled.	Government of France	Ministère de la Transition écologique et solidaire	France
12045	21	1	21	18	The selection of CDR approaches excludes a number of techniques discussed in the literature, but about which evidence is currently limited. Whilst a detailed analysis of those is not warranted in the scenarios (as per page 24, line 7 to 16), equally it would be unfortunate not to at least reference some of those and, perhaps to signal their potential removals capacity whilst clearly recognising the evidence shortages. I would suggest referencing Macroalgae, Oceanic Carbon Capture and Storage, down and up-welling (for which field trials have now been conducted and which was referenced on the SR 1.5), crop residue oceanic sequestration and building with biomass. Brief overviews of these techniques are available – see references. These suggest a combined maximum theoretical capacity of +50GtCO2e Ref: GESAMP 2019. High Level Review of a Wide Range of Proposed Marine Geoengineering Techniques. GESAMP Reports and Studies. Joint Group of Experts on the Scientific Aspects of Marine Environment Protection. And FLORIN et al., 2020. International governance issues on climate engineering - Information for policymakers. International Risk Governance Centre (IRGC). Lausanne, Switzerland: EPFL Scientific Publications http's://innocence/record/277726. Greenhouse Gas Removal. London: Royal Society and Royal Academy of Engineering https://royalsociety.org/topics-policy/projects/greenhouse-gas-removal/?gclid=EAIaIQobChMIg8292JCR7wIVjZntCh1MRgOVEAAYASAAEgIdHPD_BwE	Noted - ocean-based approaches have been added.	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
14969	22	1			As CDR forms the backbone of most IPs presented in this assessment, it is important to cover individual options but also possible CDR combinations with a more explicit focus on more overarching risks and feasibility, also in the context of shortcomings in current IAM designs. Please also see this recent publication by Rueda et al. (2021) on 1.5°C compatible CDR portfolios in this regard: https://www.sciencedirect.com/science/article/pii/S0959378021000170. Ideally, section 12.3 would be extended with a concluding subsection that pulls all relevant CDR aspects together that are particularly relevant in the context of the Paris Agreement (which includes statements on equity and responsibilities of industrialised countries in Article 4).	Accepted - a new reference has been added.	Government of Saint Kitts an	Department of Environment - Ministry of Agriculture, Marine Resources, Cooperatives, Environment and Human Settlements	Saint Kitts and Nevis
20161	22	1	22	1	See also (on IAMs and CDR): Johansson, D. J., Azar, C., Lehtveer, M., & Peters, G. P. (2020). The role of negative carbon emissions in reaching the Paris climate targets: The impact of target formulation in integrated assessment models. Environmental Research Letters, 15(12), 124024.	Accepted - a new reference has been added.	Nikas Alexandros	National Technical University of Athens	Greece
70533	22	1	38		The start of this CDR section needs one or two paragraphs summarising the apparent political status and acceptance of different CDR techniques in the context of debates around geoengineering. Conventions such as the CBD and London Protocol place a de facto moratorium on geo-engineering, though interpreting this in practice is challenging. Would the authors agree that techniques such deep ocean sequestration, ocean fertilisation and enhanced weathering are more controversial than CCS using geological formations and A/R (either on a logical basis or because they are happening already therefore de facto accepted). Whether or not A/R can be considered a 'Nature Based Solution' is also relevant to this (though perhaps better addressed in Ch7).	Rejected. CDR is not geoengineering.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
65479	22	2	22	4	Is it worth including permanently in this definitions as well? Or is it covered by durability?	Noted. Durability included in new figure	Albertine Pegrum-Haram	European Climate Foundation	United Kingdom (of Great Britain and
1611	22	4			products are ccus not cdr	Rejected - storing CO2 in "durable" products essentially amounts to CDR.	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and
46159	22	4	22	4	Please replace: "these technologies" with "these processes, approaches and technologies" COMMENT: CDR is (as defined in the previous sentences) not restricted to technologies.	Accepted. Wording changed	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
44057	22	5	22	6	12.22. 5-6 “One can usefully distinguish between ecosystem-based and technological options” I suggest clarifying that the distinction between “ecosystem-based” and “technological” options is quite uncertain and questionable. i.e. a large afforestation project could be a substantial alteration of the pre-existing ecosystem, whereas enhanced weathering could be seen as an acceleration of natural processes.	Accepted. Categorisation changed (also in figure)	Stefano Caserini	Politecnico di Milano	Italy

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
46161	22	5	22	6	Please explain what the clustering is useful for, and why alternative clusterings with stronger link to the political discourse of individual measures, like e.g. governability, have not been used. Please mention also the need for distinct criteria to classify measures in a useful way, also referring to the differences in clusterings compared to the Emissions Gap Report 2017. An example for alternative clustering (with explicit criteria) in "policy-relevant categories (Decisive, Low Regret, Concept Stage)" can be found in Gattuso et al. (2021), Frontiers in Climate, "The Potential for Ocean-Based Climate Action: Negative Emissions Technologies and Beyond", https://doi.org/10.3389/fclim.2020.575716. In addition, we are not convinced of the attribution of CDR-methods to the classes provided in this report. E.g., for soil carbon sequestration and afforestation some kind of technological intervention is often needed (e.g. when trees are planted in areas they wouldn't naturally exist). For that reason they would also fit to the category "technological and geochemical", similar to enhanced weathering. The Gap Report classifies biochar as "natural" while in this report it is "combined", without explanation. Please improve.	Accepted. Categorisation changed (also in figure)	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
1613	22	6			enhanced weathering is half natural,as biological processes accelerate it	Accepted. Categorisation changed (also in figure)	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and
22125	22	7	22	7	for the statement "more vulnerable to reversal" we suggestion to add "i.e. less resilient"	Accepted. Figure completely revised	Government of France	Ministère de la Transition écologique et solidaire	France
12597	22	13	22	16	Please consider splitting up the talk about "Enhanced Weathering" into: 1. Enhanced Weathering, the natural way: Spreading rockdust on (agricultural) land or beaches, and let nature do its thing (using ambient and soil CO2) => we just move stuff into a more favorable position to speed up the natural process. => Low Energy Usage, needs somewhat more time, plus natural upsides 2. Enhanced Weathering, the technical way (some also call this "accelerated weathering"): Using rockdust in "processing places" (greenhouse, reactors, etc.) to let it react with (concentrated) CO2 (e.g. from a climeworks plant, from CCS) => we use lots of machinery to speed up the process even more. More Energy usage, but also more speed. Both is "enhanced weathering", but the usage and effects are very much different. In both cases the carbon is brought back "into geology". In this context I would like to point to: Seddon N, Smith A, Smith P, et al.: Getting the message right on nature-based solutions to climate change. Glob Change Biol. 2021;00:1–29. https://doi.org/10.1111/gcb.15513	Accepted. Figure completely revised	Dirk Paessler	Carbon Drawdown Initiative	Germany
79185	22	13	22	24	The manner EW is described, especially in Figure 12.4, where CO2 is converted and/or bound into new minerals seems more an apt description of mineral carbonation. Enhanced weathering is focussed on the weathering (dissolution) reaction products increasing surface waters' accomodation for CO2 uptake.	Accepted: Modify the enhanced weathering description in Fig 12.4 to read "minerals react with CO2 and bind them in new minerals or dissolved products"	Francesc Montserrat	University of Amsterdam	Netherlands
113	22	18	22	19	Shouldn't Fig. 12.4 reflect the risks of geoengineering involved?	Accepted. Figure completely revised	Harry Aiking	Vrije Universiteit, Institute for Environmental Studies	Netherlands
1615	22	18	22	19	beccs is more expensive than enhanced weathering. graphic ignores all calcining processes eg 10.1038/s41467-020-16510-3	Accepted. Figure completely revised	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and
8773	22	18	22	19	Why is 'ocean fertilisation' included under 'Combined'? It does not fit in this category as there is little or no technology involved. It should be in the 'Ecosystem-based' category. It was not included in the original figure in Chapter 7 of the UNEP Emissions Gap Report of 2017.	Accepted. Figure completely revised	Chris Vivian	Retired ex Cefas	United Kingdom (of Great Britain and Northern Ireland)
43367	22	18	22	19	The Figure 12.4 could have a better quality so it is possible to read what is written. Thank you.	Accepted. Figure completely revised	BEATRIZ BECCARI BARRETO	Politecnico di Milano	Brazil
46163	22	18	22	18	"based on figure ? from Chapter 7": Reference is missing, please add number of figure.	Accepted. Figure completely revised	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
8155	22	19	22	24	Figure 12.4: Please add the option of increased substitution of fossil-fuel intensive materials by biomaterials as "carbon capture and usage" to the "combined" column. This is the sequel to e.g. "A/R/ improved FM" from the left panel.	Accepted. Figure completely revised	Joachim Rock	Thuenen-Institute of Forest Ecosystems	Germany
46165	22	19	22	24	Figure 12.4: Please add the option of increased substitution of fossil-fuel intensive materials by biomaterials as "carbon capture and usage" to the "combined" column. This is the sequel to e.g. "A/R/ improved FM" from the left panel.	Accepted. Figure completely revised	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
76913	22	19	22	20	Figure 12.4: As described, "Blue carbon" may not be actual "CO2 removal" : it is described as CO2 take up without the requirement that it is due to "deliberate human activity" to increase the sink. I assume that the figure relates to "anthropogenic removals" as defined in the glossary, so all types of options should follow this definition (the definition may also be clarified in the caption). Furthermore, the definition of "blue carbon" in the glossary does not imply that it always relate to a human action to increase sinks : in itself, "blue carbon" does not imply anthropogenic removal. This is similar to the forestry case : for consistency in the figure as well as due to the definition above, there is a need to define each option as an increase in sink due to deliberate human action (as done with the reference to afforestation etc.). That could be something like "blue carbon ecosystem restoration" for example : please adapt as needed.	Accepted. Figure completely revised	Philippe Marbaix	Université catholique de Louvain	Belgium

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
57757	22	20	22	24	The acronym "TRL" is not defined in the caption to Figure 12.4 and later in Table 12.6. This appears to mean "Technology Readiness Level" with a scale of one through nine. A definition and citation for this term would be useful.	Accepted: Spelled out	Government of United State	U.S. Department of State	United States of America
18481	22	22	22	23	I don't understand the footnotes in the caption; I can't see scales for cost or TRL	Accepted - clarified	Government of United Kingd	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
70535	22	23	22	23	figure 12.4 , what is TRL?	Accepted: Spelled out	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
70537	22	24	22	29	Please clarify the resasons for the gap between IAM deployment levels and sectoral pathways. The point about DACCS not belonging to an economic sector does not fully explain it because IAM CDR at the moment is predominantly A/R & BECCS. Is it because sectoral studies are not so closely linked to the total CDR requirement imposed by the temperature goals?	Noted - we take note of the deficiency of the IAM elsewhere. We however had to cut down on the sentence because of the length limit.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
1443	22		22		figure 12.4 has low quality	Accepted. Figure completely revised	Hamideh Dalaei	climatologist at Islamic Republic of IRAN Meteorological Organisation	Iran
3201	22		22		figure 12.4 has low quality. It should be noted that there are low quality figures in the IPCC Chapters as usual.	Accepted. Figure completely revised	Hamideh Dalaei	climatologist at Islamic Republic of IRAN Meteorological Organisation	Iran
43439	22		22		figure 12.4 has low quality. It should be noted that there are low quality figures in the IPCC Chapters as usual.	Accepted. Figure completely revised	sadegh zeyaeyan	Head of national center for forecasting and weather hazards management of Islamic Republic of Iran Meteorological Organization (IRIMO)	Iran
50345	22		22		figure 12.4 has low quality. It should be noted that there are low quality figures in the IPCC Chapters as usual.	Accepted. Figure completely revised	Government of Iran	Islamic Republic of Iran Meteorological Organization (IRIMO)	Iran
46167	23	1	23	39	WG I SOD (Ch. 5.6.2.1.3, p. 93, l. 40-42) states: "In other words, an emission of CO2 into the atmosphere is more effective at raising atmospheric CO2 than an equivalent CO2 removal is at lowering it, particularly for larger emissions/removals." This is in contrast to assumed full equivalence (in terms of cost), which we believe must be assumed within IAMs during the optimisation process. However, this ESM feature suggests that - at least for "net negative emission" scenarios - a tonne of CO2 removed by CDR should not be given the same value as a tonne of CO2 emission. This important finding of WG I needs to be clearly addressed here please.	Noted - clarification of this point added in chapter 3.5	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
46169	23	1	23	1	Please change the title of this subsubsection 12.3.1. . The expectation to find a description of the "State of CDR" is certainly not met. We suggest removing the subsubsection since it is part of the introduction to CDR in section 12.3.	Accepted - the subsection header has been dropped.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
54367	23	1	23	22	Recommend to focus on what is new since SR1.5 and SRCCL (e.g. as in chpt. 7).	Accepted. Done as part of hard section edit	Sabine Fuss	MCC Berlin	Germany
18483	23	2	23	2	"CDR can be used" is too strong a statement. The "significantly higher volumes" referred to later in the paragraph are highly speculative. Please replace "CDR can be used" with "CDR has been proposed".	Taken into account - not in main text anymore but in Cross-Chapter Box, with a better differentiation between CDR for net zero and CDR for net negative	Government of United Kingd	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
46171	23	2	23	2	Please substitute "CDR can be used to complement" with "CDR can complement" to avoid any policy prescriptive reference to the deployment of CDR in favour of GHG-mitigation.	Taken into account - not in main text anymore but in Cross-Chapter Box, with a better differentiation between CDR for net zero and CDR for net negative	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
12047	23	7	23	10	What constitutes a 'comprehensive strategy' is unclear. However, I suggested it is noted that the United Kingdom has committed to CDR, particularly DACCS, and set out a programme to deliver its objectives. In June 2020 the UK government announced up to £100 million of new funding to develop direct air capture technologies. As part of this they seek the development of CDR technologies to achieve commercialisation. The UK Gov states 'To meet net zero by 2050 direct air capture and other greenhouse gas removals technologies are necessary to offset emissions from hard to tackle areas, such as parts of the agriculture and aviation sectors.' See https://www.gov.uk/government/publications/direct-air-capture-and-other-greenhouse-gas-removal-technologies-competition	Taken into account - different terminology used now. UK GGR policy now used as example in case study box 12.1 in 12.3.3	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
22127	23	9	23	9	It would be useful to define what "comprehensive CDR strategy" mean in this context.	Taken into account - different terminology used now. UK GGR policy now used as example in case study box 12.1 in 12.3.3	Government of France	Ministère de la Transition écologique et solidaire	France
8775	23	10	23	15	There are also concerns that this mitigation deterrence concern will obstruct research being done on CDR techniques.	Accepted - clarified	Chris Vivian	Retired ex Cefas	United Kingdom (of Great Britain and
46173	23	10	23	10	Please add: "could, depending on the design of emission reduction schemes, cause "mitigation deterrence" and obstruct…." (the term "mitigation deterrence" is the technical term, e.g. used by Markusson).	Taken into account - suggested change partly implemented, but without using the terminology explicitly to avoid confusion, given that CDR is part of mitigation (in addition to emissions reductions)	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
57759	23	10	23	15	Authors could more clearly frame these concerns as potential social barriers to deployment.	Rejected - these are not necessarily barriers to deployment. And barriers (along with enabling conditions) are assessed in the feasibility section.	Government of United State	U.S. Department of State	United States of America
70539	23	10	23	15	Among the concerns, some CDRs have important negative environmental impacts (i.e. ocean-based).	Accepted - the proposed concern has been added.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
80215	23	10	23	15	This section should use the academic terms of art for each of these phenomena, namely; moral hazard, slippery-slope, technological lock-in, and polarization driving social and geopolitical conflict, which are used in each of the papers cited. Their omission both impedes understanding and policy relevance, and threatens neutrality. See, as referenced in Ch.12: Minx, Jan C., et al. "Negative emissions—Part 1: Research landscape and synthesis." Environmental Research Letters 13.6 (2018): 063001.	Noted - this is an assessment, not a review, but technical terms have been incorporated to the extent that is useful.	Kelly Wanser	SilverLining	United States of America
19551	23	11	23	11	Please revise as follows: "There are concerns that the prospect of large-scale CDR could obstruct near-term emission reduction efforts (Morrow 2014; Markusson et al. 2018)." Reason: CDR is increasingly understood as a form of the 'mitigation of climate change', time-relevance in 'mitigation obstruction' concerns need to be clearly spelled out.	Accepted - clarified	Matthias Honegger	Utrecht University, Perspectives climate research, IASS-Potsdam	Germany
22129	23	15	23	15	here 'dedicated CDR governance' is rather neutral and coming at the end of this § it would mean a governance mechanism keeping in check the various risks and impacts listed above. However, il section 12.7.1 below it becomes a governance geared towards 'accelerating' and 'incentizing' CDR. This discrepency should be addressed by rewriting section 12.7.1 taking into account developments in chapter 3	Taken in to account - deleted the adjective ("dedicated"), since it leads to widely different interpretations	Government of France	Ministère de la Transition écologique et solidaire	France
46175	23	15	23	15	Please delete "highlighting the need for dedicated CDR governance". Comment: Throughout the AR6-draft other authors draw different conclusions to the abovementioned concerns regarding large-scale CDR. In addition, the statement is policy-prescriptive.	Taken in to account - deleted the adjective ("dedicated"), since it leads to widely different interpretations	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
46177	23	16	23	17	The sentence is misleading: The extend of using biological-based CDR methods in history is not nearly matching the extend implied in scenarios. In addition, even if these methods have been applied in the past, the intention was not to remove carbon from the atmosphere. Please add "… although not with the intention to remove carbon from the atmosphere, and at much smaller scales than assumed in IAM-based scenarios." or similar.	Accepted - added.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
8777	23	17	23	17	Insert '/geochemical' after 'technological' to be consistent with the category in Figure 12.4.	Accepted - figure has been completely redrawn and categorisation made more consistent	Chris Vivian	Retired ex Cefas	United Kingdom (of Great Britain and
12599	23	17	23	18	NO! EW *is not* necessarily a "**technological approach**". Please consider splitting up "Enhanced Weathering" into: 1. Enhanced Weathering, the natural way: Spreading rockdust on (agricultural) land or beaches, and let nature do its thing (using ambient and soil CO2) => we just move stuff into a more favorable position to speed up the natural process. => Low Energy Usage, needs somewhat more time, plus natural upsides. *** THIS is not a technological approach. *** Especially when rock dust (basalt, olivine) is used in agriculture for EW (e.g. 40 tons of basalt per hectar) it can remove CO2 at substantial rates while not competing with food production in any way. To the contrary, farmers can expect improved cop yields due to nutrients from the rocks and improved pH of the soil. 2. Enhanced Weathering/"accelerated weathering": Using rockdust in "processing places" (greenhouse, reactors, etc.) to let it react with (concentrated) CO2 (e.g. from a climeworks plant, from CCS) => we use lots of machinery to speed up the process even more. More Energy usage, but also more speed. *** THIS IS a technological approach. *** See: Seddon N, Smith A, Smith P, et al.: Getting the message right on nature-based solutions to climate change. Glob Change Biol. 2021;00:1–29. https://doi.org/10.1111/gcb.15513	Accpted: Replaced 'technological' with 'other'	Dirk Paessler	Carbon Drawdown Initiative	Germany
57761	23	18	23	18	Is there a citation to support the text that few policies exist to incentivize the use of technical CDR approaches?	Accepted - references have been added, but sentence moved to 12.3.3	Government of United State	U.S. Department of State	United States of America
46179	23	23	23	39	The list of assumed IAM-based figures of CDR deployment is presented here without the required framing and interpretation. This is clearly inadequate to get a balanced picture on "the state of CDR". The first sentence only hints at feasibility challenges of rapid upscaling, but no further context is given. However, much more consideration should be made or - if given elsewhere - should be clearly referenced. 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.” This seems the place where such an interpretation is absolutely required: It should cover topics such as the discounting and intergenerational justice implications, the lack of impact costs in IAMS especially in overshoot scenarios, the end point of the IAM optimization in 2100 (follow-up costs of large CDR infrastructures which are then not anymore fully needed), political economy of delayed action (possibly including the resistance of some industrial interest groups to a phase out their business model), mitigation deterrence effects not being represented in IAMs, the tendency of IAMs to well represent techno-economic processes, but inability to represent social/multi-actor governance aspects, e.g. of land-use, also the asymmetry of the earth system response to emissions and removal (see Ch 5.6.2.1.3 of WG I SOD) and consequences for a cost-optimal consideration of CDR within IAMs.	Accepted - clarified	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
46181	23	23	23	25	The term "uncertain" is rather unspecified. The whole sentence should be rephrased to clarify the message. It seems, that a general judgement on the feasibility / the likelihood / or the challenge for reaching the following deployment figures is meant. Indeed, any judgement that can be made from the literature regarding the required scale-up would be welcome. e.g. these CDR volumes imply an increase in CCS capacity of roughly a factor 10 per decade for the next decade (for BECCS and DACCS) which is not underpinned by historic developments etc.	Accepted - clarified by rewording.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
54369	23	23	23	39	This is very interesting, since SR1.5 and SRCCL the scenario spectrum and included CDR options have evidently widened. Maybe a figure could illustrate the ranges over the technologies and practices over different time periods. More importantly, it would be very good to explain why the lower end of the cumulative removal range is so much higher (5 times!) than in SR1.5.	Accepted - a lower bound of Carbon Sequestration has been added.	Sabine Fuss	MCC Berlin	Germany
65481	23	25	32	26	Does land-based equate to your prior definition of ecosystem-based? Per Figure 12.4 or does it include the 'combined' category. Please specify. Later you use the definition AFOLU vs. Technological CDR. It makes it confusing to follow what types are categorized where when it is inconsistent.	Accepted - we have harmonised terminology	Albertine Pegrum-Haram	European Climate Foundation	United Kingdom (of Great Britain and Northern Ireland)
57763	23	28	24	33	Sequestration under AFOLU depends on many factors. Given that most sequestration occurs in forests, the effect of any AF/RF approach depends on the amount of land, the timing of planting, the species planted, site quality, etc. Figure 12.5 shows a lift occurring from CDR approaches from 2005-2070 then a decline. This would suggest slower growing species, but it is unclear in the text what assumptions are made and how realistic the assumptions are.	Noted. The figure shows many IAM scenarios that model land use, including A/R, in different ways. The modelled outputs reflect a range of different forest types, locations, and maturity of forests, all with different marginal costs. In addition, land use carbon removal "competes" with other options in terms of the marginal costs.	Government of United State	U.S. Department of State	United States of America
65483	23	33	23	34	Would it be possible to split these numbers by the C1/2/3 classification defined in Chapter 3? i.e. how much do C1 scenarios differ from C3, would be a very valuable metric.	Rejected - space constraint precludes us from doing so.	Albertine Pegrum-Haram	European Climate Foundation	United Kingdom (of Great Britain and
18485	23	34	23	34	Please insert "IAMs invoke" before "cumulative CDR..." and follow this sentence with an assessment of whether or not these volumes are likely to be feasible, given the evidence about the GGR technologies presented in the report and the caveats which are well-summarised higher up page 23. In the AR5 there was a disconnect bewteen the IAMs and the evidence and this mistake should not be repeated here.	Accepted - clarified.	Government of United Kingd	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
70541	23	34	23	36	How can the CDR volumes needed to reach 1.5 be less than what is needed to reach 2°?	Noted - 2-degree scenarios and 1.5-degree scenarios are not based on the exactly identical set of models, and because of such differences, the apparent discrepancy is not unexpected. The sentence in question was nevertheless dropped for brevity.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
15761	23	37	23	39	"New studies have identified some reasons for large-scale CDR deployment" this is an extremely relevant point which should be further investigated in the report, rather than just briefly mentioned. Are VRE deployment and a high discount rate the only two reasons worth mentioning here?	Accepted - the reasons are now more elaborated.	Sara Budinis	International Energy Agency	France
18487	23	37	23	39	This sentence "New studies have identified some reasons for large-scale CDR deployment, including some barriers to VRE deployment, a high discount rate, among others (Köberle 2019; Emmerling et al. 2019; Hilaire et al. 2019)." is problematic. VRE is not defined in the chapter, neither is it in the glossary, I'm guessing it means variable renewable energy. But a barrier to variable renewables is not a reason to rely on CDR or any other unproven technology of uncertain potential. CDR also faces barriers, some are the same as those facing VREs, including high discount rates. I woud strongly recommend that this sentence is removed. Alternatively, the sentence needs re-writing and the 3 papers' messages need to be critically appraised and better explained.	Accepted - rephased.	Government of United Kingd	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
22131	23	37	23	39	The added value of this sentence is not very clear : the above paragraphs highlights the role of CDR deployment in relation with 1,5°C and 2°C targets; are the reasons mentionned here different from the perspective of reaching these targets? How do they articulate with the rest of the paragraph?	Accepted - clarified.	Government of France	Ministère de la Transition écologique et solidaire	France
46183	23	37	23	37	"New studies have identified some reasons for large-scale CDR deployment ..." The sentence is unclear: Are reasons for the prominent and large-scale inclusion of CDR in IAMs found in these studies? Please clarify.	Accepted - clarified	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
46185	23	37	22	39	The first part of this sentence is meaningless. Please elaborate more on "some reasons for large-scale CDR deployment". Do you mean in model studies? And what is VRE?	Acepted - clarified and the acronym removed.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
47699	23	37	23	39	As part of the EMF-33 project, an analysis has been done in order to look into the use of bioenergy technologies including BECCS (Daioglou et al., 2020). One interesting conclusion of that study was that the use of BECCS was not required in a case where drastic reductions in energy demand via efficiency and/or lifestyle change measures. This further corroborates the outcomes of the van Vuuren et al. (2018) and Grubler et al. (2018) studies. Daioglou, V., Rose, S. K., Bauer, N., Kitous, A., Muratori, M., Sano, F., ... & van Vuuren, D. P. (2020). Bioenergy technologies in long-run climate change mitigation: results from the EMF-33 study. Climatic Change, 163(3), 1603-1620.	Accepted - references have been added.	Vassilis Daioglou	Utrecht University	Netherlands
54371	23	37	23	39	Something seems to be missing in the sentence.	Accepted - we clarified the CDR deployment level is about those assumed in the IAM scenarios.	Sabine Fuss	MCC Berlin	Germany
65485	23	37	23	39	This sentence does not make sense to me. What is VRE?	Accepted - VRE is variable renewable energy and is now spelled out.	Albertine Pegrum-Haram	European Climate Foundation	United Kingdom (of Great Britain and
11489	23	38	23	38	It is not clear what "VRE" stands for. Suggest giving its full name somewhere in the main text.	Accepted - VRE is variable renewable energy and is now spelled out.	SAI MING LEE	Hong Kong Observatory	China

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
22133	23	38	23	38	About the acronym CDR, does it mean Variable Renewable Energy? We suggest to define the abbreviations in each chapter if they are to be used	Accepted - VRE is variable renewable energy and is now spelled out.	Government of France	Ministère de la Transition écologique et solidaire	France
22135	23	38	23	38	We recommand to explain the link between a high discount rate and the need for large-scale CDR deployment	Accepted - clarified	Government of France	Ministère de la Transition écologique et solidaire	France
70543	23	38	23	38	what is VRE?	Accepted - VRE is variable renewable energy and is now spelled out.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
54373	24	1	24	5	Please increase resolution of figure. (This actually applies to most of the figures in the chapter).	Accepted - a high-res figure is now included.	Sabine Fuss	MCC Berlin	Germany
15637	24	2	24	2	The "AFOLU" should come fist and BECCC-DAC-EW come later in the legend considering the postions of figures.	Accepted - corrected.	Suil Kang	Gwangju Institute of Science and Technology	Republic of Korea
16573	24	2	24	2	The "AFOLU" should come fist and BECCC-DAC-EW come later in the legend considering the postions of figures.	Accepted - corrected.	Government of Republic of K	Korea Meteorological Administration (KMA)	Republic of Korea
18489	24	4	24	4	What does "OS" stand for? I can't find a definition either in the chapter or in the glossary.	Accepted - spelled out (overshoot)	Government of United Kingd	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
70545	24	4	24	4	OS; Ocean sequestration?	Accepted - spelled out (overshoot)	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
44059	24	7	24	16	It's worth adding here that there could be integration between different CDR options. Caserini et al. (2019) proposed a techno-economic assessment of a process that combines BECCS and ocean alkalinity enhancement. These possibilities are not yet captured by IAM. Caserini S., Barreto B., Lanfredi C., Cappello G., Ross Morrey D., Grosso M. (2019) Affordable CO2 negative emission through hydrogen from biomass, ocean liming, and CO2 storage. Mitigation and Adaptation Strategies for Global Change. 24(7), 1231-1248. https://doi.org/10.1007/s11027-018-9835-7 (already cited in the chapter)	Rejected - the list of CDR options that are not included in IAMs is vast, and we cannot mention every single study here. In addition, the paper is cited in a different section of Chapter 12.	Stefano Caserini	Politecnico di Milano	Italy
46187	24	7	24	16	Please clarify in this paragraph that the limited numbers of CDR options considered and explored in IAM scenarios as of the writing of this assessment does not allow for the conclusion that these CDR options are more promising than others since the choice of methods considered is not based on a systematic scientific assessment. Please explain the reasons why the literature on and techno-economic assessment of other options are yet to emerge.	Accepted - It is simply because these technologies are relatively new in the literature, and there is not much literature compared to more established options such as forestry and BECCS. We changed the text accordingly.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
8779	24	10	24	10	Add Keller et al. (2014) and Keller et al. (2018) to Strefler et al. 2018: Keller, D. P., Feng, E. Y., & Oschlies, A. (2014). Potential climate engineering effectiveness and side effects during a high carbon dioxide-emission scenario. Nature Communications, 5, 3304. https://doi.org/10.1038/ncomms4304 Keller, D. P., Lenton, A., Scott, V., Vaughan, N. E., Bauer, N., Ji, D., … Zickfeld, K. (2018). The Carbon Dioxide Removal Model Intercomparison Project (CDRMIP): rationale and experimental protocol for CMIP6. Geosci. Model Dev., 11(3), 1133–1160. https://doi.org/10.5194/gmd-11-1133-2018	Noted - the text concerns IAM scenarios, not scenarios produced by earth system models. Clarified accordingly.	Chris Vivian	Retired ex Cefas	United Kingdom (of Great Britain and Northern Ireland)
8875	24	17	24	21	Kato and Kurosawa (2021, Sustainability Science) can be an emerging literature for the national level CDR studies.	Accepted - added.	Etsushi Kato	Institute of Applied Energy	Japan
22137	24	17	24	17	Should a word on global assessments be included? for instance: Morais TG, Teixeira RFM, Domingos T (2019) Detailed global modelling of soil organic carbon in cropland, grassland and forest soils. PLoS One 14:1–27. https://doi.org/10.1371/journal.pone.0222604 Ledo A, Hillier J, Smith P, et al (2019) A global, empirical, harmonised dataset of soil organic carbon changes under perennial crops. Sci Data 6:1–7. https://doi.org/10.1038/s41597-019-0062-1	Rejected. Assessment of the potential for soil carbon sequestration is already assessed and discussed in Section 7.4.3.1. Not a cross-sectoral issue	Government of France	Ministère de la Transition écologique et solidaire	France
12049	24	19	24	20	In addition to high costs, the likely high energy requirements might usefully be introduced here?	Accepted - clarified.	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
54375	24	22	24	24	One reason could also be the aforementioned lack of regional/national analyses, see e.g. https://www.frontiersin.org/articles/10.3389/fenrg.2020.553400/full No need to cite specifically, but just to show that sustainable potentials can be found (also in industry) that are not accounted for in IAMs.	Accepted - a reference added.	Sabine Fuss	MCC Berlin	Germany
57765	24	22	24	29	This is a very noteworthy point and it needs to be highlighted more in the discussion and perhaps noted in the conclusions and SPM. If IAMs do not have options for a set of CDR technologies, the sectoral and cross-sectoral opportunities and changes associated with those options need to be assessed differently -- without IAMs.	Noted - we take note of the deficiency of the IAM elsewhere. We however had to cut down on the sentence because of the length limit.	Government of United State	U.S. Department of State	United States of America
12063	25	1	27	31	If large scale DACCS were adopted, it will be essential to have transparent MRV of achieved sequestration in place. This will be required to monitor global progress against climate change targets, and to provide accurate accounting of states' contributions and any carbon sequestration credits that may accrue. This could usefully be noted in this section Ref: ZAKKOUR, P. K., J: DIXON, T 2014. Incentivising and Accounting for Negative Emission Technologies. Energy Procedia, 63, 6824-6833.	Accepted - this point is now addressed in the governance subsection.	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
12463	25	1	34	1	What is missing is a discussion of non-CO2-GHG removal technologies. Most notably technologies for CH4 removal through oxidation would be relatively low cost compared to CO2-removal technologies. Examples are soil methanotrophy (oxidation of methane by bacteria in soil), methane capture, and UV-photocatalysis analogous to natural oxidation of atmospheric CH4 by OH or Cl radicals. See: Nisbet et al, "Methane Mitigation: Methods to Reduce Emissions, on the Path to the Paris Agreement", https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019RG000675. A specific technology you could mention, next to the ones mentioned in the Nisbet article, are iron-salt aerosols, which enhance the natural generation of chlorine atoms from sea salt aerosols. See: https://link.springer.com/article/10.1007/s10874-016-9336-6.	Accepted - non-CO2 GHG removal has been added.	Maarten Van Herpen	Acacia Impact Innovation BV	Netherlands
12467	25	1	34	1	What is missing is a discussion of non-CO2-GHG removal technologies. It is important to add this to the chapter, because in chapter 3 it is written: "There are other options discussed in the literature, like methane capture (Jackson et al. 2019); however, the role of these options in long-term mitigation pathways has not been quantified and thus they are excluded here. Chapter 12 includes a more detailed description of the individual technologies, including their costs, potentials, financing, risks and impacts. "	Accepted - non-CO2 GHG removal has been added.	Maarten Van Herpen	Acacia Impact Innovation BV	Netherlands
16607	25	1	25	1	It focuses on capture technology and economics, but it needs to be considered about storage technology and methods. Discussions on storage exploration and safety issues should be added.	Accepted - the reference to Chapter 6 added.	Government of Republic of K	Korea Meteorological Administration (KMA)	Republic of Korea
57767	25	1	32	30	Section 12.3.2 needs a set up paragraph clarifying the point of the section, which presumably is to put the DACCS, EW, and OBAs in front of readers, explain what they are, where the science is, and what the key knowledge gaps are. It should caution that -- while readers will see cost, sequestration, timelines, and lists of potential benefits and trade-offs -- one important conclusion is no one can yet say to what extent these approaches may be feasible (technically or economically) or even desirable.	Accepted - an introductory paragraph has been added.	Government of United State	U.S. Department of State	United States of America
22139	25	3	25	3	When used as a title, giving the complete name would bring clarity.	Accepted - spelled out.	Government of France	Ministère de la Transition écologique et solidaire	France
80217	25	3	27	31	Chapter 12 is missing a discussion of Solar Radiation Management as a means to mitigate climate impacts. Developments in both research and institutional activity since AR5 warrant treatment at the section (12.x) level, and in the executive summary (noted in a separate comment). Following the section 12.3.2.1 template on DACCS (P. 25 Line 3 to P. 27 Line 31): Status: SAI and MCB research is still early and very little technology has been developed - however, plans for field experiments (Keith 2014, Wood 2017, Dykema 2014) have matured substantially in the light of recent assessments (National Academies 2015) and modeling results (Tilmes 2018, Kravitz 2018). Two leading field experiment candidates (Harvard University SCOPEX and University of Washington LAFE) have received philanthropic funding but have not yet deployed. The 2015 National Academy of Sciences assessment highlighted the need for an integrated SRM research agenda, which led to the formation of a new NAS study panel in 2018 to formulate this agenda as well as a research governance plan. This work is still ongoing, with publication scheduled for Aug 2020. In 2019, an NGO successfully lobbied the United States Congress to include federal support for climate intervention research in its 2020 budget (Wanser 2019). Research efforts in other countries, primarily consisting of modeling studies and governance research, most with modest philanthropic or governmental support, including a substantial research effort in China (United States 2017). Several proposals have noted the 'dual-purpose' potential for solar radiation management research to reduce key climate uncertainties, such as aerosol-cloud interactions and stratospheric chemistry (NAS 2015, Wood 2017, Fahey 2020). Costs: Recent analyses of SAI incorporating aircraft engineering design considerations and payload/flight plan estimates from recent modeling studies have estimated an annual cost of $2.25B per annum in direct delivery costs to achieve a radiative forcing of -0.25W/m^2 per year (Smith 2018). Informal expert polling suggests an equivalent MCB system would cost $3-4B per year. Programmatic budgets estimates that layer in comprehensive support functions (such as observational platforms for monitoring deployment, model analysis, personnel, security, and governance and reporting) suggest a likely operational cost of a global SRM capability of $15-20B per annum using either SAI or MCB	Rejected - SRM is dealt with in other parts of the report (e.g., Chapter 14 has a cross working group chapter and a section on governance).	Kelly Wanser	SilverLining	United States of America
7709	25	4			it suggested that transfer of greenhouse gases to Deep Ocean be noticed for coastal industries like thermal power stations, refineries, and other industrial factories as an appropriate solution for coastal countries.	Rejected - the storage issue is dealt with in Chapter 6.	Leila Rashidian	Meteorological	Iran
9029	25	4	25	4	it suggested that transfer of greenhouse gases to Deep Ocean be noticed for coastal industries like thermal power stations, refineries, and other industrial factories as a appropriate solution for coastal countries.	Rejected - the storage issues is dealt with in Chapter 6.	Behzad Layeghi	IRIMO	Iran
43373	25	4	25	4	DACCS shares with conventional CCS the transportation, not only storage, I would say. I believe it would be nice to separate both of them.	Accepted - clarified.	BEATRIZ BECCARI BARRETO	Politecnico di Milano	Brazil

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
60495	25	4	25	15	In this paragraph, the role of DAC + CO2 mineralisation should be cited as a solution to store CO2 permanently and create negative emissions. 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).•Ostovari et al., 2020, Sustainable Energy Fuels, 4, 4482-4496.•Di Maria et al, 2020, International Journal of Greenhouse Gas Control, 93.•Hills et al., 2020, frontiers in Energy Research, 8 :142.•SAPEA, 2018, Science Advice for Policy by EU Academies, Novel Carbon Capture and Utilisation Technologies-Research and Climate Aspects, Evidence Review Report, 2.•Beuttler et al., 2019, Frontiers n Climate, 1 :10.•Breyer et al., 2019, Joule, 3, 2053-2057.	Noted - however, Chapter 6 discusses utilization more fully and this section focuses on the capture part. The role of minerization is now clarified.	Célia Sapart	Université Libre de Bruxelles / CO2 Value Europe	Belgium
83739	25	4	25	15	In this paragraph, the role of DAC + CO2 mineralisation should be cited as a solution to store CO2 permanently and create negative emissions. 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).•Ostovari et al., 2020, Sustainable Energy Fuels, 4, 4482-4496.•Di Maria et al, 2020, International Journal of Greenhouse Gas Control, 93.•Hills et al., 2020, frontiers in Energy Research, 8 :142.•SAPEA, 2018, Science Advice for Policy by EU Academies, Novel Carbon Capture and Utilisation Technologies-Research and Climate Aspects, Evidence Review Report, 2.•Beuttler et al., 2019, Frontiers n Climate, 1 :10.•Breyer et al., 2019, Joule, 3, 2053-2057.	Noted - however, Chapter 6 discusses utilization more fully and this section focuses on the capture part. The role of minerization is now clarified.	Christian Breyer	LUT University	Finland
1619	25	6			hydroxide isnt really a solvent. this is an acid base reaction	Rejected - while correct, "liquid solvent" is widely used (even in a review paper)	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and
1617	25	7			ignores electro swing like verdox	Accepted - added.	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and
15763	25	7	25	7	Utilisation should not be mentioned under DACCS in order to avoid further confusion on this topic	Accepted - DACCU is now spelled out and distinguished from DACCS	Sara Budinis	International Energy Agency	France
1597	25	8	25	8	A metric needs to be established for "permanent." Many researchers deem terrestrial sequestration to be long-term, but not permanent.	Accepted - clarified.	Wil Burns	Institute for Carbon Removal Law & Policy, American University	United States of America
57769	25	10	25	10	Should edit for clarity. Reads as if centuries and millennia do not count as long-term removal.	Accepted - clarified.	Government of United State	U.S. Department of State	United States of

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
60493	25	10	25	15	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, 2019a.b, 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. REFERENCES : •Ramboll, 2019, The Institute for Advanced Sustainability Studies CESR, CEDelft and IOM Law.•Wich et al. 2020, Frontiers Energy Research, 7, 162.•SAPEA, 2018, Science Advice for Policy by EU Academies, Novel Carbon Capture and Utilisation Technologies-Research and Climate Aspects, Evidence Review Report, 2.•Zimmerman et al., 2018 , CO2 Chem Media and Publishing Ltd.•Styring et al., 2011, Carbon Capture and Utilization in the Green Economy. Centre for Low Carbon Futures, York.•Von der Assen et al., 2013, Energy Environ. Sci. 6, 2721–2734.•Zhu, 2019, Clean Energy, Vol. 3, No. 2, 85–100.•Kätelhön et al., 2019, PNAS, 116, 23, 11187-11194.•Bruhn et al., 2016, Environmental Science & Policy, 60, 38–43.•IEAGHG, 2019a: Putting CO2 to Use – Creating value from emissions, International Energy Agency. •IEAGHG, 2019b: Exploring Clean Energy Pathways: the role of energy storage, International Energy Agency.•Nocito and Dibenedetto, 2020, Current Opinion in Green and Sustainable Chemistry, 21, 34–43. •Wich et al. 2020, Frontiers Energy Research, 7, 162.•Nocito and Dibenedetto, 2020, Current Opinion in	Noted - utilization is discussed mainly in Chapter 6 (energy). We however now highlight the need for life cycle life-cycel assessment.	Célia Sapart	Université Libre de Bruxelles / CO2 Value Europe	Belgium
78829	25	10	25	15	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, 2019a.b, 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. REFERENCES : •Ramboll, 2019, The Institute for Advanced Sustainability Studies CESR, CEDelft and IOM Law.•Wich et al. 2020, Frontiers Energy Research, 7, 162.•SAPEA, 2018, Science Advice for Policy by EU Academies, Novel Carbon Capture and Utilisation Technologies-Research and Climate Aspects, Evidence Review Report, 2.•Zimmerman et al., 2018 , CO2 Chem Media and Publishing Ltd.•Styring et al., 2011, Carbon Capture and Utilization in the Green Economy. Centre for Low Carbon Futures, York.•Von der Assen et al., 2013, Energy Environ. Sci. 6, 2721–2734.•Zhu, 2019, Clean Energy, Vol. 3, No. 2, 85–100.•Kätelhön et al., 2019, PNAS, 116, 23, 11187-11194.•Bruhn et al., 2016, Environmental Science & Policy, 60, 38–43.•IEAGHG, 2019a: Putting CO2 to Use – Creating value from emissions, International Energy Agency. •IEAGHG, 2019b: Exploring Clean Energy Pathways: the role of energy storage, International Energy Agency.•Nocito and Dibenedetto, 2020, Current Opinion in Green and Sustainable Chemistry, 21, 34–43. •Wich et al. 2020, Frontiers Energy Research, 7, 162.•Nocito and Dibenedetto, 2020, Current Opinion in	Noted - utilization is discussed mainly in Chapters 6 (energy) and 11 (industry). We however now highlight the need for life cycle assessment.	Sylvain Nizou	CEA	France

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
83737	25	10	25	15	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, 2019a.b, 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. REFERENCES : •Ramboll, 2019, The Institute for Advanced Sustainability Studies CESR, CEDelft and IOM Law.•Wich et al. 2020, Frontiers Energy Research, 7, 162.•SAPEA, 2018, Science Advice for Policy by EU Academies, Novel Carbon Capture and Utilisation Technologies-Research and Climate Aspects, Evidence Review Report, 2.•Zimmerman et al., 2018 , CO2 Chem Media and Publishing Ltd.•Styring et al., 2011, Carbon Capture and Utilization in the Green Economy. Centre for Low Carbon Futures, York.•Von der Assen et al., 2013, Energy Environ. Sci. 6, 2721–2734.•Zhu, 2019, Clean Energy, Vol. 3, No. 2, 85–100.•Kätelhön et al., 2019, PNAS, 116, 23, 11187-11194.•Bruhn et al., 2016, Environmental Science & Policy, 60, 38–43.•IEAGHG, 2019a: Putting CO2 to Use – Creating value from emissions, International Energy Agency. •IEAGHG, 2019b: Exploring Clean Energy Pathways: the role of energy storage, International Energy Agency.•Nocito and Dibenedetto, 2020, Current Opinion in Green and Sustainable Chemistry, 21, 34–43. •Wich et al. 2020, Frontiers Energy Research, 7, 162.•Nocito and Dibenedetto, 2020, Current Opinion in	Noted - utilization is discussed mainly in Chapters 6 (energy) and 11 (industry). We however now highlight the need for life cycle assessment.	Christian Breyer	LUT University	Finland
57771	25	11	25	12	Certainly synthetic fuels and some plastics may be short-lived, but it seems odd to suggest that building materials may not be long-lived. This would seem to be an exception rather than a rule.	Accepted - corrected.	Government of United State	U.S. Department of State	United States of America
1621	25	14			wood might last decades. paper lasts months. concrete lasts much lomger than the buildings it makes up -likely millions of years	Noted - we clarified our description but base the description on a peer-reviewed paper.	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and
46967	25	16	25	19	This paragraph asserts that all DAC approaches fall into three categories: thermal swing liquid solvent approaches, thermal swing solid sorbent approaches, or humidity swing solid sorbent approaches. It's true that this covers the best developed technologies, but there are emerging or at least suggested alternatives, including electro-swing DAC (Voskian and Hatton 2019, DOI 10.1039/C9EE02412C) and thermal swing carbonate looping DAC (McQueen et al 2020, DOI 10.1038/s41467-020-16510-3). (McQueen's carbonate looping could be seen as a form of enhanced weathering, but because it ends with geological sequestration of compressed supercritical CO2, I think it's better classified as DAC.) I don't think this paragraph needs to do more than mention these technologies and point out that additional approaches to DAC are emerging.	Accepted - other approaches are noted and references added.	David Morrow	American University	United States of America
1623	25	18			ignores electro swing	Accepted - other approaches are noted and references added.	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and
43375	25	19	25	21	I would say that it is not only innovation that attracted entrepreneurs and investors, but also the higher social acceptance than other CDR methods.	Rejected - we tend to agree but we note that social acceptance cannot be demonstrated with the peer-review literature.	BEATRIZ BECCARI BARRETO	Politecnico di Milano	Brazil
47855	25	22	25	42	There are at present several funding programs under the US Department of Energy (ARPA-E, Office of Science, etc.) that do address material science and systems integration challenges for DAC - as a separate technology and in combination with CCS technology retrofitting where a portion of the excess process heat can be utilized to provide low cost process heat to DAC.	Noted - the issue raised cannot be supported by the peer literature. We however note the ongoing R&D activities.	Patrick Lamers	NREL	United States of America
47857	25	22	25	42	The integration (and related ongoing research efforts) of DAC with CCS technologies retrofitted to condensation power plants (without process heat usage) is missing. This concept is particularly promising for solvent based DAC processes. Ongoing research project in this area are presently funded by the US Department of Energy's ARPA-E Program under the FLECCS FOA. https://arpa-e.energy.gov/technologies/programs/fleccs	Noted - the issue raised cannot be supported by the peer literature. We however note the ongoing R&D activities.	Patrick Lamers	NREL	United States of America
57773	25	25	25	32	The two highlighted statements are in conflict. As written, the second is incorrect. From the first statement, private companies are investing in DAC systems, but existing DAC technologies are not currently economical at scale. So the price of captured CO2 must increase and/or the cost of capture using DAC technologies must come down enough to be competitive with other CCS systems.	Rejected - high costs are already noted above.	Government of United State	U.S. Department of State	United States of America
15765	25	29	25	30	"This can be contrasted with a target, mature system of a 1 MtCO2 yr-1 capture rate, which is three orders of magnitude larger." What does this mean? Are you making a comparison between the previously mentioned projects and the Oxy Low Carbon Ventures project in the Permian basin, or just referring to how large a large scale plant could be?	Noted - the sentence removed because of space consideartion and for clarity.	Sara Budinis	International Energy Agency	France
70547	25	32	25	35	this sentence could be cut	Accepted - deleted as it concerns with the technical detail.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
12051	25	35	25	42	The $140m Gov. led R&D programme focussed on TRL acceleration in the UK could usefully be referenced here. See https://www.gov.uk/government/publications/direct-air-capture-and-other-greenhouse-gas-removal-technologies-competition	Noted - the issue raised cannot be supported by the peer literature. We however note the ongoing R&D activities.	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
46189	25	35	25	35	Please delete: "An RD&D program dedicated to DAC would therefore be required" and replace with: "An RD&D program dedicated to DAC is therefore proposed by some..." COMMENT: This sounds too much like a policy-prescriptive recommendation.	Accepted - corrected.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
57775	25	35	25	35	Revise to: "A public RD&D ..."	Accepted - corrected.	Government of United State	U.S. Department of State	United States of
15767	25	43	26	8	Given the cost of DAC (especially its operating cost) is its main barrier right now, the section could be expanded in order to mention cost reduction potential	Accepted - the text in the cost subsection has been revised.	Sara Budinis	International Energy Agency	France
1625	25	45			cement + ccs is cdr ,because of environmental reaction, as is magnesium oxide weathering 10.1038/s41467-020-16510-3. these use ccs technology	Accepted - "cannot serve as CDR" has been dropped to avoid confusion.	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and
46969	25	45	25	45	This line says that CCS "cannot serve as CDR," but this is only true of fossil CCS. Other places in the report are clear about this. Consider amending to "cannot serve as CDR except when used with bioenergy."	Accepted - "cannot serve as CDR" has been dropped to avoid confusion.	David Morrow	American University	United States of America
57777	25	45	25	45	Need to explain why DAC cannot serve as CDR. It must be a definition reason, which people can change. Technically it makes no sense. If CO2 is captured before it is emitted, it does not count. But if that same CO2 is captured the hour after it is emitted by a DAC (or any other) system, it counts. This needs to be explained.	Accepted - "cannot serve as CDR" has been dropped to avoid confusion.	Government of United State	U.S. Department of State	United States of America
78783	25	48	26	8	the findings in Breyer et al. (https://www.cell.com/joule/fulltext/S2542-4351(19)30413-1) would indicated to lower the lower end of DACCS to 50 USD/tCO2. This could have not been found by other studies, as latest and thus most competitive solar PV cost based on Vartiainen et al. (https://onlinelibrary.wiley.com/doi/full/10.1002/pip.3189) are applied in Breyer et al. and this for full hourly resolution in a 0.45 degree resolution globally. It has been concluded by Jaxa-Rozen (https://www.nature.com/articles/s41558-021-00998-8) that IAMs are negatively biased against solar PV, while non-IAMs present a more realistic view on the development of PV-based solutions. This shall be factored in the reassessment of lowering the lower end to 50 USD/tCO2 for DACCS.	Rejected - the suggested reference is a systems analysis, not a technoeconomic analysis focused on DAC.	Christian Breyer	LUT University	Finland
81035	26	1	32	21	DAC has a disproportionate amount of investment and commercial interest as a CDR option at this point in time, and therefore more research, however the ocean-based approaches offer dramatically larger scale potential without the energy use limitations or innovations required to bring the price down to feasible ranges. Further, ocean-based approaches offer much greater co-benefits in the form of ecosystem services, reversal of acidification, benefits to the food web, etc that DAC does not. Therefore, more space should be given to ocean-based approaches as they will likely prove to be the technologies and processes that lead to CDR on the scale required to limit global warming to well below 2 degrees C.	Rejected: There is no space available to expand the ocean-based CDR sections	Eric Matzner	Project Vesta	United States of America
61853	26	7	26	8	Breyer et al. 2019b did not consider nuclear as an option for powering DAC, and is therefore biased and not technology neutral. In their earlier work (Breyer et al., 2019a, https://doi.org/10.1007/s11027-019-9847-y), they mentioned that "It should be noted that a constraint has been applied to block new fossil fuel and nuclear power installations after 2015." Further, in hydrogen production, nuclear is cheaper than solar or wind due to the significantly higher capacity factor. Further still, Breyer et al. 2019b acknowledge 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 6,000-8,000 full load h per year, which requires a constant energy supply incompatible with the previous notion of only excess electricity utilization." In this perspective, nuclear would seem to be the best option to power DAC.	Rejected - we mention the importance of clean energy sources (we use the word "low-carbon" to implicitly include nuclear) already, and the literature has produced quantitative estimates for DAC w ith renewables but not the one with nuclear.	Rauli Partanen	Think Atom	Finland
65893	26	7	26	8	Breyer et al. 2019b did not consider nuclear as an option for powering DAC. In (Breyer et al., 2019a, https://doi.org/10.1007/s11027-019-9847-y), they mentioned that "It should be noted that a constraint has been applied to block new fossil fuel and nuclear power installations after 2015." In hydrogen production, nuclear is cheaper than solar or wind due to the significantly higher capacity factor. Further, also Breyer et al. 2019b acknowledge 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 6,000–8,000 full load h per year, which requires a constant energy supply incompatible with the previous notion of only excess electricity utilization." From this perspective, nuclear would seem to be the best option to power DAC. Please explain this inconsistency and revise accordingly.	Rejected - we mention the importance of clean energy sources (we use the word "low-carbon" to implicitly include nuclear) already, and the literature has produced quantitative estimates for DAC w ith renewables but not the one with nuclear.	Eero Hirvijoki	Aalto University	Finland
46191	26	10	26	10	Please add : "is virtually unlimited provided the high energy requirements could be met" COMMENT: This current sentence is misleading, since the cited authors do restrict the "limited" potential (e.g. Lawrence, M. G., and Co-authors, 2018: Evaluating climate geoengineering proposals in the context of the Paris Agreement temperature goals. Nat. Commun., 9, 3734, https://doi.org/10.1038/s41467-018-05938-3, p. 8). Energy consumption is not only a risk but a precondition for effectiveness.	Accepted - the proposed phrase has been added.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
12053	26	13	26	13	Fuss 2018 suggests 0.5 to 5 GtCO2yr, perhaps this ought be used rather than up to.	Accepted - corrected.	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)

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57779	26	13	26	13	Annex B implies that currency values should be in 2015 USD or 2015 International Dollars, but Euros (without a dollar year) are used here.	Accepted - corrected.	Government of United State	U.S. Department of State	United States of America
54377	26	14	26	15	Also because of barriers to and time needed for upscaling.	Accepted - corrected.	Sabine Fuss	MCC Berlin	Germany
46193	26	15	26	19	Concerns about the scale-up of DACCS does not include institutional, economic and/or societal constraints, but focuses only on the technical potential. This picture is incomplete. Please also refer to societal, economic and political feasibility.	Noted - a reference on political economy and upscaling policy has been added.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
78785	26	15	26	16	Breyer et al. (https://www.cell.com/joule/fulltext/S2542-4351(19)30413-1) showed that a much faster scaling of DACCS then presented in Realmonte et al. is possible, linking to the analogy of the solar PV deployment - thus better to present both views on industrial scalability of DACCS in this section.	Rejected - the suggested reference does not present an original analysis on upscaling.	Christian Breyer	LUT University	Finland
46971	26	16	26	29	This paragraph is missing a discussion of Fuhrman et al. 2020 (DOI 10.1038/s41558-020-0876-z), which studies DAC in GCAM. Like Marcucci et al 2017, they find that DAC substitutes for BECCS, reducing pressure on land use and food prices (even though they emphasize that food prices still rise because there's still a lot of BECCS in the system).	Accepted - a suggested reference has been added in a different subsection on CDR and IAM scenarios	David Morrow	American University	United States of America
57781	26	20	26	40	The energy requirements of Direct Air Capture with Carbon Storage (DACCS) could be clarified, especially electricity requirements. The energy consumption numbers cited on this page are a combination of heat and electricity. It would help if they can be split into separate heat and electricity requirements for 10 GtCO2 per year sequestration, and this electricity requirement compared to current world consumption of electricity. This is important because economy-wide electrification will also require costly expansion of the electricity distribution grid.	Accepted - numbers of electricity have been added.	Government of United State	U.S. Department of State	United States of America
15769	26	21	26	21	I think here it would be interesting to distinguish between the land footprint of the DAC plant alone and the land footprint of DAC plus its source of energy and heat, especially when coming from a renewable source	Accepted - the suggested point has been added.	Sara Budinis	International Energy Agency	France
1629	26	22			dac land footprint is only small if you use nuclear energy	Accepted - the suggested point has been added.	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and
70175	26	22			(Smith et al. 2016). Although considering even 1GtCO2 scales, the land footprint for energy generation infrastructure alone may become an issue. An area much larger than the city of Los Angeles would be required for natural gas powered DACCS, and many times the state of Delaware if using solar (National Academies of Sciences, 2019 ; Sekera & Lichtenberger, 2020). In addition, transportation infrastructure will be required for the captured CO2. The land surface requirements for the removal of 1GtCO2 could rival that of the existing petroliium pipeline system (Mac Dowel et al. 2017) . https://cmi.princeton.edu/wp-content/uploads/2019/12/Pacala-NAS-study-2019.pdf ; https://link.springer.com/article/10.1007/s41247-020-00080-5 ; https://www.nature.com/articles/nclimate3231	Accepted - the suggested point has been added.	Rayner Andersen	Department of Fisheries and Oceans	Canada
1627	26	23			minimum theoretical energy ignores additionality eg in cement with ccs, where calcining energy is already accounted for and separation from air is passive	Noted - this point has been clarified by adding "gas"	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and
78011	26	23	26	23	Reportedly Lackner's "mechanical trees" capture carbon from dry air without fans or extra heat using natural wind flow and moistrue swings. Reportedly 12 of columns capture about 1 metric C02/day so that a "farm" of 1200 occupying an area of 2-3 square kilometers will capture 3.8 million metric tons CO2/annually. Additional energy and water is necessary to move and moisturize the sorbent, and to store and if necessary further purify the CO2, but (unless I'm not understanding or missing something) this process appears to use much less than the 0.5 GJ t/CO2 cited on p. 26, line 23? (See: https://www.reuters.com/article/us-usa-climatechange-carboncapture/do-mechanical-trees-offer-the-cure-for-climate-change-idUSKCN1S52CG and https://news.asu.edu/20191205-popular-science-picks-lackner-mechanicaltree-2019-top-technology). Also, Global Thermostat's technology uses excess heat from conventional fossil fuel power I23ation to produce carbon negative fossil fuel powered electrcity. This appears to be the ultimate "cross sectoral" technolog+I19y that may resolve the problem of how to support economic development (and increased energy use) and draw down carbon at the same time using existing fossil fuels and fossil fuel infrastructure (until a full transition to renewables), that can also, reportedly, be profitable if the carbon sequestered in useful products. (See: https://www.greenbiz.com/article/inside-exxonmobils-hookup-carbon-removal-venture-global-thermostat and references in: https://www.cpegonline.org/post/arctic-sea-ice-traige-carbon-cycle-restoration-and-a-renewable-energy-and-materials-economy). The main problem appears to be time. It seems that these breakthrough technologies should be covered in this sections? For quick overviews of these technologies see (Baiman 2021). References: Baiman, Ron. 2021. In Support of a Renewable Energy and Materials Economy (REME): A Global Green New Deal (GGND) that Includes Arctic Sea-Ice Climate Triage and Carbon Cycle Climate Restoration. Submitted to the Review of Radical Political Economics. Accessed at: https://www.cpegonline.org/post/arctic-sea-ice-traige-carbon-cycle-restoration-and-a-renewable-energy-and-materials-economy	Rejected - the values found in the peer-reviewed literature (includinng those covering Global Thermostat) are inconsistent with the provided references.	Ron Baiman	Benedictine University	United States of America
18491	26	25	26	25	"the current technology.." which one? Several have been described, should this be technologies?	Accepted - made into a plural.	Government of United Kingd	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
15771	26	27	26	28	It is important to specify that low temperature heat can only be used with certain DAC technologies based on solid sorbents and is not suitable for the one based on liquid solvent, having a solvent regeneration temperature around 900 degree celsius	Accepted - clarified.	Sara Budinis	International Energy Agency	France
61855	26	27	26	31	Producing both the low-temperature heat and electricity at high capacity factors needed for cost-effective DACS would be ideal with a nuclear reactor running in combined heat and power (CHP) mode and/or with a very simple low-pressure thermal reactor providing only heat (such as DHR400 developed in China). This option should be discussed along with other options due to its very significant potential.	Rejected - there is no peer-reviewed literature on this point, and the role of nuclear has been discussed elsewhere already.	Rauli Partanen	Think Atom	Finland
65895	26	27	26	31	In discussing how the low-temperature heat needed by DACS could be sourced by renewable-powered heat pumps, I'm rather surprised that the option of producing process heat with nuclear is not explored. Dedicated for low-temperature process heat production, nuclear plants wouldn't need external cooling, turbine components, nor the expensive pressure vessel, all of this significantly reducing the costs and making nuclear ideal for the purpose. Please explain why this option has not been considered and revise the draft accordingly.	Rejected - there is no peer-reviewed literature on this point, and the role of nuclear has been discussed elsewhere already.	Eero Hirvijoki	Aalto University	Finland
5541	26	28	26	28	replace Renewables" by "low carbon sources"	Accepted - corrected.	Michel SIMON	Retraité/ Pdt d'association	France
1599	26	30	26	31	I think more emphasis should be placed on the fact that high use of renewables might divert their use from more productive sectors in terms of emissions reductions. It's not clear to everyone that increased demand fro renewables would ensure increased supply, and thus no displacement.	Noted - to avoid confusion the sentence has been removed.	Wil Burns	Institute for Carbon Removal Law & Policy, American University	United States of America
1631	26	32			missing cite for water use	Rejected - the references are provided in the following few sentences.	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and
46195	26	38	26	38	Please add the new literature: Chatterjee et al. 2020, Unrealistic energy and materials requirement for direct air capture in deep mitigation pathways, https://doi.org/10.1038/s41467-020-17203-7	Accepted - a reference has been added.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
57783	26	40	26	40	The phrase "upends the market" is too vague. Need to be more technically precise.	Accepted - reworded.	Government of United State	U.S. Department of State	United States of
15773	26	41	26	46	Please see my previous comment on land footprint i.e. it is important to distinguish DAC footprint from the footprint of the source of energy	Accepted - corrected accordingly.	Sara Budinis	International Energy Agency	France
70177	26	46			(Smith et al. 2016). Further concerns and risks exist around leakage (European Academies, Science Advisory Council 2018); fugitive emissions (Stewart and Haszeldine 2015); potential groundwater contamination and earthquakes (Clean Water Action 2017); air pollution and health damage (Jacobson 2019); and liability for environmental and health problems (Herzog 2011). https://easac.eu/fileadmin/PDF_s/reports_statements/Negative_Carbon/EASAC_Report_on_Negative_Emission_Technologies.pdf ; https://pubmed.ncbi.nlm.nih.gov/25789442/ ; https://www.cleanwateraction.org/publications/carbon-dioxide-enhanced-oil-recovery-co2-eor ; https://pubs.rsc.org/en/content/articlelanding/2019/EE/C9EE02709B ; https://www.sciencedirect.com/science/article/pii/S0140988310001921	Rejected - the raised issues concern with CCUS in general, a topic covered in Chapter 6.	Rayner Andersen	Department of Fisheries and Oceans	Canada
15775	26	48	26	48	Please note that solar and wind could power only certain DAC technologies operating at low temperature	Accepted - clarified.	Sara Budinis	International Energy Agency	France
14895	27	1			Intermittent RE peak shaving is not really an option for DACCS due to high capital costs demanding full load for cost recuperation (as explained in the wording later in the same paragraph). The sentence should read: "Discussions of DACCS as PtX technology are unlikely to stick, because..." to not lead readers on the wrong track.	Accepted - clarified.	Felix Creutzig	MCC Berlin & TU Berlin	Germany
57785	27	8	27	8	Are these aspects explored at all? If not, delete "fully".	Noted - to avoid confusion the sentence has been removed.	Government of United State	U.S. Department of State	United States of
78787	27	9	27	15	Breyer et al. (https://www.cell.com/joule/fulltext/S2542-4351(19)30413-1) pointed out that there are most likely two major waves of DAC technology application: first DACCU in reaching zero CO2 emission systems (mainly for raw CO2 material supply for synthetic fuels for high temperature heat process, and long-distance marine and aviation transportation); and second DACCS for net-negative CO2 emission systems. This would imply a strong rational for DAC support and incentives as a most important dual-use technology.	Noted - we believe these points are already covered. The commented lines discuss trade-offs and spillover effects and do not concern with the very motivation of DAC (which is already discussed at the beginning of the seciton).	Christian Breyer	LUT University	Finland
46197	27	16	27	19	To "postpone the timing of mitigation" is a major risk of CDR options. Please portray this more balanced and highlight that DACCS is not yet as developed as to fulfil these mitigation simulations.	Rejected - the point raised is covered elsewhere in the CDR section. Also the need for DAC R&D has been emphasized, indicating immaturity of the technology.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
57787	27	16	27	29	Make clear what the price of carbon is. Given the rest of the section, it is reasonable to assume the prices that got these models to solve are very high and/or very speculative.	Accepted - the point has been incorporated.	Government of United State	U.S. Department of State	United States of America
29045	27	21	27	22	The potential cited for DACCS should be discussed more critically. It will be severely limited by energy and costs, similar as potential for BECCS is limited by sustainable biomass and land. So care needs to be taken, otherwise we move from the 'overreliance' on BECCS to the next potential overreliance in scenarios/models.	Noted - we believe these points are already covered in the subsection on potentials.	Jasmin Kemper	IEAGHG	United Kingdom (of Great Britain and Northern Ireland)
1633	27	31			entire section ignores role of dac in making e-fuels (eg sunfire)	Noted - it is already briefly mentioned in the opening paragraph. Also, CCUS is treated in Chapter 6.	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
75713	27	32	32	23	Disclosure: I am Executive Director of Project Vesta, which is a non-profit focused on coastal enhanced weathering of olivine. I am an author on Stopnitzky et al (2021), submitted for publication and to IPCC. Project Vesta and other groups are planning a series of lab and in situ experiments in this field to characterize the risks and benefits of this technique. Coastal enhanced weathering shows significant potential, with more study needed. I suggest adding specific mentions of coastal enhanced weathering given i) the body of evidence which supports the potential and ii) the different characteristics of coastal enhanced weathering as compared with other forms of weathering (such as land weathering) and ocean alkalinity enhancement (such as ocean liming).	Accepted: Cross referenced coastal environments in Section 12.3.2.2 first paragraph. Added "coastal environments" to Ocean Alkalinity description page 29 section 12.3.2.3	Tom Green	Far Away Projects	United States of America
79187	27	32	29	6	The section 12.3.2.2 discusses Enhanced Weathering (EW). According to the strict(est) definition of EW used here, EW results in binding atmospheric CO2 in newly formed minerals. This is -to my knowledge- Mineral Carbonation, rather than EW. The section on EW fails to mention Coastal Enhanced Weathering (CEW).	Noted: We already note bicarbonate formation in 12.3.2.2	Francesc Montserrat	University of Amsterdam	Netherlands
12601	27	33	27	44	Rock dust can not only be "spread on soil", it should rather be mixed into the biologically active top layer (10-50 cm) of the soil where CO2 density is 10-1000 times higher than the 0,04% of ambient air. This speeds up the CO2 binding process substantially. There are various projects that aim to build a proper accounting mechanism for this.	Noted: How the material is spread, or mixed is a level of detail in which there is little published work	Dirk Paessler	Carbon Drawdown Initiative	Germany
65243	27	33	27	44	Enhanced weathering can also be applied on the coasts, where wave energy is used to accelerate comminution. Coastal enhanced weathering was described, modeled and tested experimentally in two papers (Meysman, F.J. and Montserrat, F. (2017) Biol Lett 13.; Montserrat, F., Renforth, P., Hartmann, J., Leermakers, M., Knops, P. and Meysman, F.J. (2017) Environ Sci Technol 51, 3960-3972.) and should be cited in this paragraph as an example of potential enhanced weathering solution. In the current version of the report, both studies (Montserrat and Meysman 2017, Meysman et al. 2017) simply appear between p12-31 l.46 and p12-32 l.2 to support that dissolution by-products other than alkalinity constituents released in the ocean upon weathering. Both studies actually show substantial alkalinity release in seawater upon olivine dissolution. Citing these studies just in the context of risks and impacts and not mention coastal enhanced weathering as a manner of sequestrating CO2 seems unfair.	Partially accepted: As previously noted: Cross referenced coastal environments in Section 12.3.2.2 first paragraph. Added "coastal environments" to Ocean Alkalinity description page 29 section 12.3.2.3.- Montserrat / Meysman 2017 does not include unique experimental results. Montserrat et al., 2017 does not report substantial alkalinity release, and it is not clear how closely the method simulates 'real world' attrition in the surf.	Olivier Sulpis	Universiteit Utrecht	Netherlands
12065	27	45	27	46	Suggest more recent evidence re trials is included. For example, AMANN, T. H., J.: STRUYF, E.: DE OLIVEIRA GARCIA, W.: FISCHER, E. K.: JANSSENS, I.: MEIRE, P.: SCHOELYNCK, J. 2020. Enhanced Weathering and related element fluxes – a cropland mesocosm approach. Biogeosciences, 17, 103-119 MCQUEEN, N. K., PETER: DIPPLE, GREG: RENFORTH, PHIL: WILCOX, JENNIFER 2020. Ambient weathering of magnesium oxide for CO2 removal from air. Nature Communications, 11, 3299.	Partially accepted: we have cited the Amman et al. (2020) paper but not the McQueen et al. (2020) paper due to the hybrid mineralisation approach described, which adds undue complexity to the section	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
1635	27	46			project vesta now has a large trial going	Noted: This work has yet to be published	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and
12067	28	1	28	6	Suggest adding reference to the need for further research re political and social agenda, including regulatory and incentive frameworks (i.e., governance) - as suggested in BEERLING, D. J. K., EURIPIDES P.: LOMAS, MARK R.: WADE, PETER: EUFRASIO, RAFAEL M.: RENFORTH, PHIL: SARKAR, BINOY: ANDREWS, M. GRACE: JAMES, RACHAEL H.: PEARCE, CHRISTOPHER R.: MERCURE, JEAN-FRANCOIS: POLLITT, HECTOR: HOLDEN, PHILIP B.: EDWARDS, NEIL R.: KHANNA, MADHU: KOH, LENNY: QUEGAN, SHAUN: PIDGEON, NICK F.: JANSSENS, IVAN A.: HANSEN, JAMES: BANWART, STEVEN A. 2020. Potential for large-scale CO2 removal via enhanced rock weathering with croplands. Nature, 583, 242-248.	Noted: This work is already cited in this part of the document	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
12069	28	7	28	16	Suggest adding some more recent cost assessments. For example, Beerling (2020) shows China, India, the USA and Brazil have EW potential to help achieve average global CDR goals of 0.5 to 2 Gt of CO2 per year, with extraction costs of approximately US$80–180 per tonne of CO2. Average costs in the USA were US$160–180 per tonne of CO2 and in Canada and the European nations there was a slightly larger range of US$160–190 per tonne of CO2. These are almost 50% higher than China, India, Mexico, Indonesia and Brazil (US$55–120 per tonne of CO2). BEERLING, D. J. K., EURIPIDES P.: LOMAS, MARK R.: WADE, PETER: EUFRASIO, RAFAEL M.: RENFORTH, PHIL: SARKAR, BINOY: ANDREWS, M. GRACE: JAMES, RACHAEL H.: PEARCE, CHRISTOPHER R.: MERCURE, JEAN-FRANCOIS: POLLITT, HECTOR: HOLDEN, PHILIP B.: EDWARDS, NEIL R.: KHANNA, MADHU: KOH, LENNY: QUEGAN, SHAUN: PIDGEON, NICK F.: JANSSENS, IVAN A.: HANSEN, JAMES: BANWART, STEVEN A. 2020. Potential for large-scale CO2 removal via enhanced rock weathering with croplands. Nature, 583, 242-248.	Accepted: Reference to Beerling et al 2020 with cost estimates now included. Page 28 ~line 18 onward	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
1637	28	17	28	25	ignores marine	Accepted: Cross referenced coastal environments in Section 12.3.2.2 first paragraph. Added "coastal environments" to Ocean Alkalinity description page 29 section 12.3.2.3	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and Northern Ireland)
12071	28	17	28	25	Suggest adding a comment noting that recent literature about potentials have suggested that the approach, when in-situ maybe up to three times less efficient than had been previously suggested AMANN, T., HARTMANN, J., STRUYF, E., DE OLIVEIRA GARCIA, W., FISCHER, E. K., JANSSENS, I., MEIRE, P. & SCHOELYNCK, J. 2020. Enhanced Weathering and related element fluxes – a cropland mesocosm approach. Biogeosciences, 17, 103-119.	Accepted: Reference to Amann et al 2020 now included on Page 28 Line 18 onwards	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
57789	28	18	28	19	Why are the tropics the area with the most sequestration potential? It is not intuitive. The explanation is given on page 79, lines 28-30, but few will get that far.	Accepted: "a region considered promising given the higher temperatures and greater rainfall " now included on page 28 L20.	Government of United State	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
75053	28	21	28	21	It should be noted that the estimate of 95Gt CO2/4.9 GtCO2 is at the upper end of the estimates reported within the paper (and not the mean) and you might want to cite here as well Amann et al. (2020), EnhancedWeathering and related element fluxes – a cropland mesocosm approach, stating "Derived rates of ... for coarse and fine material, respectively, based on the outlet water, are about 1 order of magnitude lower than values published for an olivine-amended soil column experiment (Renforth et al., 2015) and about 3 orders of magnitude lower than theoretical optimum dissolution rates given in Strefler et al. (2018)." (p.112)	Accepted: Text changed such that the estimates in Strefler et al., 2018 are notes as 'upper', additional estimates from Beerling et al., 2020 and Amann eta l., 2020 are also included.	Wilfried Rickels	Kiel Institute for the World Economy	Germany
70549	28	23	28	23	The ocean - singular form is better suited.	Accpted: Changed	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
1639	28	26	28	30	ignores dust effects on health ,climate ,ecosystems and atmos chem	Accepted: Additional reference to potential risk from dust included, but no work has been published on the potential impact.	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and
4617	28	26	28	30	Still, the risks of mining/extracting rocks for enhanced weathering purposes are likely lower, considering for instance acid mine drainage which is an important environmental concern in mining for various (mainly sulfide mineral-associated) metals. As rocks used for EW are likely low in sulfide mineral content (compared to sulfidic ore deposits), acid mine drainage is less of a problem.	Accepted: Changed text from "any mineral" to that "mineral construction aggregates".	Glenn Bark	Luleå University of Technology, Sweden	Sweden
70551	28	26	28	30	indications on the orders of magnitude involved would be useful. What does this represent compared to current mining operations?	Noted: No work has been published on the environmental impact associated with mining for EW.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
22141	28	29	28	30	The sentence suggests that potential employment can offset environmental impacts. Rephrase: "These risks should be balanced against potential benefits in poverty reduction through employment of local manpower in mining"	Accepted: Implemented	Government of France	Ministère de la Transition écologique et solidaire	France
291	28	31	28	41	Amann & Hartmann (2019) reviewed co-benefits of Enhanced weathering- biochar-bioenergy plants and summarized in a key-figure the benefits of co-deployment of CO2-removal methods, by optimizing the C-pool per area optimizing the co-delpoyment efforts. Nutrient release and retention due co-delpoyment could increase the C-uptake by plants. Therefore, combining methods remains a major research effort. This might be added. In addition in the section for biochar and bioenergy his perspective might be mentioned. Citation: Amann, T., & Hartmann, J. (2019). Ideas and perspectives: Synergies from co-deployment of negative emission technologies. Biogeosciences, 16(15), 2949-2960.	Noted: Too specific an example to include given the limited space	Jens Hartmann	Universität Hamburg	Germany
1641	28	31	28	41	ignores coastal erosion prevention from beach placing	Noted: But no space to include	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and
12073	28	31	28	41	Suggest adding a comment regarding the potential of enhanced weathering to function as a nutrient source for bioenergy-grasses and natural growing forests, in addition to any carbon sequestration potential. See DE OLIVEIRA GARCIA, W. A., T.: HARTMANN, J.: KARSTENS, K.: POPP, A.: BOYSEN, L. R.: SMITH, P.: GOLL, D. 2020. Impacts of enhanced weathering on biomass production for negative emission technologies and soil hydrology. Biogeosciences, 17, 2107-2133.	Noted: Already mentioned these benefits, just not specfic to energy grasses	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
3933	28	32			Carbon protecting from soil erosion is only true if this carbon is organic, and only in some cases. It does not work for inorganic carbon as carbonates. The reference (Wright and Upadhyaya 1998) is not correct here since it refers to fungal activity and the influence on organic carbon and soil aggregate stability, which is completely different from the process of carbonate synthesis from silicate weathering. Please delete the statement that carbon from carbonates protects from soil erosion, because the relationship is very remote and affected by many other factors.	Accepted: added clarification: "through increased soil organic matter levels"	Rosa M Poch	ITPS and UdL	Spain
3937	28	33		34	These effects are minor and soil + climate specific. As stated before, they will not have any co-benefit in semiarid-arid climates with calcareous soils. It must be stressed to prevent misinterpretations.	Accepted: added clarification: "in some soils"	Rosa M Poch	ITPS and UdL	Spain
3935	28	35			The reference Yu et al 2017 refers to the application of organic amendments to increase organic carbon, it does not apply here.	Accepted: added clarification above: "through increased soil organic matter levels"	Rosa M Poch	ITPS and UdL	Spain
57791	28	47	28	49	The assessment of the extra demand on future energy systems being "marginal" is a value judgment and should be deleted.	Accepted: sentence deleted	Government of United State	U.S. Department of State	United States of America
15639	29	3	29	4	The sentence tells that there is only one study, but, the Table12.6 in page 3, showes that a few IAMs incldued EW. It is checked whether which information is correct.	Noted: But only one published by cut off date	Suil Kang	Gwangju Institute of Science and Technology	Republic of Korea
16575	29	3	29	4	The sentence tells that there is only one study, but, the Table12.6 in page 3, showes that a few IAMs incldued EW. It is checked whether which information is correct.	Noted: But only one published by cut off date	Government of Republic of K	Korea Meteorological Administration (KMA)	Republic of Korea
44043	29	4	32	23	"OA" is often used for "Ocean Acidification". So I suggest using through the chapter the term "OAE" (Ocean alkalinity enhancement) or or AOA (Artificial ocean alkalinization)	Rejected: term OA is used in mist literature sources and defined in the IPCC glossary	Stefano Caserini	Politecnico di Milano	Italy
22143	29	7	29	7	"Ocean based approaches" would be clearer if the three methods were distinctly separated and each time described and associated it with its potential, risks and costs. Especially as the last one, blue carbon, is more a solution based on nature.	Noted: Already separated in text and table, no space to do it in more details	Government of France	Ministère de la Transition écologique et solidaire	France
29557	29	7	29	7	Please consider to include more information regarding blue carbon in general, and especially with regards to potential opportunities for different nature-based solution for enhanced carbon uptake in especially coastal areas. We also read with interest the mitigation potential of whales as outlined in the IMF report (https://www.imf.org/external/pubs/ft/fandd/2019/12/natures-solution-to-climate-change-chami.htm) Is it something to be included in this chapter? If it is not valid.	Noted: agree, but no space to do it in more details	Government of Norway	Norwegian Environment Agency	Norway
65487	29	7	29	9	Please could you explain this 40% number a bit clearer? It does not read well with the 24% CO2 uptake suggested in Chapter 9 WG1 (multidecadal mean 1960-2018). See Friedlingstein et al., 2019. Could you maybe explain the difference in C and CO2 uptake, and could you provide a timeline for this 40% estimate Not clear	Taken onto account: combined with other comments - based on several references defined a range 30-40%	Albertine Pegrum-Haram	European Climate Foundation	United Kingdom (of Great Britain and Northern Ireland)

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
74925	29	7	32	30	On Blue carbon only seaweeds farming has been reviewed, other like Tropical Seagrass Meadows, Magroves have a lot potetial in CDR and also co-benefit. This has been demostrated by Blue Carbon Trading project in Gazi village, Kenya which has cobenifit to fisheries, provision of biomass energy and also projection from coastal erosion and many others.	Noted	Government of Kenya	Kenya Meteorological Service	Kenya
79189	29	7	32	23	In the paragraph on Ocean-based appraoches, Ocean Alkalinity Enhancement does mention the dissolution of natural alkaline minerals directly added to the ocean. As it has been demonstrated by Koehler et al (2013), open-ocean OAE by adding natural alkaline minerals does not appear feasible. However, coastal OAE by use of minerals, commonly described as Coastal Enhanced Weathering (CEW), has been investigated by a small subset of the scientific community. Although CEW is thus mentioned, no further discussion takes place. This does not do justice to its potential, nor to the identification of the implementation obstacles and potential secondary effects (both positive and negative). CEW or OAE using alkaline minerals, presents an additional modus for EW, in which no conflicts in land use are identified, and in which existing industries (mining, dredging) can play a strong role, also in developing business models in which its potential can be unlocked for implementation at scale. This warrants further mention and deeper discussion. Please expand on this.	Taking into account: CEW is discussed as much as the spase of report allows	Francesc Montserrat	University of Amsterdam	Netherlands
79203	29	7	32	23	There exists an non-profit organisation with the express goal to investigate the potential and possible negative effects of coastal enhanced weathering of olivine (ultramafic alkaline mineral), called Project Vesta (PV). PV is currently setting up the infrastructure and carrying out baseline studies, for pilot studies of CEW with olivine/dunite to quantify effects of the addition of the material on the local ecosystem as well as quantification of the dissolution kinetics. PV is funded by philantropic donations, has a multidisciplinary team of associated scientists and is concentrating these funds to plan and execute a strategic research programme to address the formulated issues with CEW / OAE with alkaline minerals. PV has submitted a paper (Stopnitzky et al 2021; I am co-author on that paper) before the submission cut-off date for this AR, in which background information, methods/approaches, funding, life-cycle analyses and other features of the research programme are presented and discussed.	Taking into account: CEW is discussed as much as the spase of report allows. The paper Stopnitzky et al 2021 was not received and not found online so it could not be cited it the text	Francesc Montserrat	University of Amsterdam	Netherlands
79209	29	7	32	23	After reading sections 12.3.2.2 and 12.3.2.3, I cannot help but notice that the depth and detail given to other sections -discussing other valid and viable CDR methods and approaches- is much more than in these two sections here. Many of the other CDR methods are (also) still in pilot -or even more conceptual- stages. However, in several cases, great potential is ascribed to one or more intervention methods. Similar potential can be argued for CEW, yet it is not given a similar level of evaluation/consideration, which is not correct and hampers scientific advancement of a potentially important field. To avoid the impression of bias, it is advised to set up these sections in much the same way, and deliver a similar depth of detail as done for other methodologies.	Noted. Enhanced weathering and ocean based CDR are considered at the same level of details as other CDR methods	Francesc Montserrat	University of Amsterdam	Netherlands
81033	29	7	32	21	Section “12.3.2.1 DACCS” and “12.3.2.2 Enhanced weathering” are both consistently organized with the same sub-sections “Status, Costs, Potentials, Risks and Impacts, Co-benefits, Trade-offs and Spill over effects, Role in mitigation pathways”, however the “12.3.2.3 Ocean-based approaches (ocean fertilisation, alkalinity enhancement and blue carbon)” does not comport to that format and is organized as “Status, Efficiency/Potentials, Potential co-benefits and adverse effects, Risks and Impacts, Costs” I think it would be helpful to keep the categories consistent so comparisons can be made of DAC, EW, and Ocean-based approaches. That would probably be easier if the Ocean-based approaches themselves (ocean fertilisation, alkalinity enhancement, and blue carbon) were further fully broken out as subcategories with each topica area discussed instead of lumped together without the full discussion of each aspect for each process.	Accepted	Eric Matzner	Project Vesta	United States of America
70553	29	8	29	8	The ocean - singular form is better suited.	Accepted	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
65	29	9			The ocean has taken up approx 30% of anthropogenic CO2 emissions since the start of the Industrial Revolution 10.1126/science.aau5153	Taken onto account: combined with other comments - based on several references defined a range 30-40%	Stephanie Henson	National Oceanography Centre	United Kingdom (of Great Britain and
70555	29	9	29	9	The ocean - singular form is better suited.	Accepted	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
67	29	15			Sentence doesn't make sense "methane capture destruction modification"	Taken into account: punctuation changed. "modification of downwelling currents"	Stephanie Henson	National Oceanography Centre	United Kingdom (of Great Britain and
1643	29	15			methane needs cites. 10.1021/es204686w and https://doi.org/10.1021/es303074j accompanying	noted: methane capture is deleted	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and
12465	29	15	29	15	missing reference for 'methane capture', and the way the sentence is written, it seems to be part of 'modification of downdwelling currents', but that reference is not about methane. So I think the 'methane capture' reference is missing. For a reference of ocean based solution that captures methane, you might use this reference: https://www.researchgate.net/publication/306045046_Climate_engineering_by_mimicking_the_natural_dust_climate_control_the_Iron_Salt_Aerosols_method	noted: methane capture is deleted	Maarten Van Herpen	Acacia Impact Innovation BV	Netherlands
15641	29	15	29	15	"methane capture and desctruction" is correct based on the description on the reference.	noted: methane capture is deleted	Suil Kang	Gwangju Institute of Science and Technology	Republic of Korea
16577	29	15	29	15	"methane capture and desctruction" is correct based on the description on the reference.	noted: methane capture is deleted	Government of Republic of K	Korea Meteorological Administration (KMA)	Republic of Korea

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69	29	18			Please check WGI glossary (and WG1 Chapter 5.6) to ensure definition of blue carbon is consistent	Accepted	Stephanie Henson	National Oceanography Centre	United Kingdom (of Great Britain and
74923	29	18	29	19	The line has refered to Chapter 4 and 5 of WG1 of AR 6, which is not available at the time of review of this document. Therefore, hard to review ocean based CDR in this chaapter.	Noted: AR6 WGI report is already available	Government of Kenya	Kenya Meteorological Service	Kenya
11869	29	20	29	33	Compare to fertilization and productivity effect in arable soils. Fertilization in agriculture with precision is easier than this example and should be more emphasized as a CDS in agriculture.	Noted: discussed in Land related section	The Royal Swedish Academy	Kung. Skogs-och Lantbruksakademien	Sweden
46199	29	20	29	33	This chapter illustrates the potentially positive impacts of ocean fertilization for CDR but does not refer to trade offs and negative consequences for marine biodiversity. Especially under the CBD a precautionary approach is crucial and risks should be reflected in this chapter by mentioning additional studies. Also Para 32 on page 31 on "risks and impacts" does not address this point adequately. Please revise.	Taken into account: section is reorganised. Risks and impacts are considered separately	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
71	29	21			The current consensus range is 5-12 GtC per year 10.1002/2013GB004743	Taken into account: based on several references the range is defined as 4-12 GtC per year	Stephanie Henson	National Oceanography Centre	United Kingdom (of Great Britain and
75	29	22	29	26	Please reconsider the wording and numerical values given here: a useful reference is https://www.nature.com/articles/ngeo1765	Noted	Stephanie Henson	National Oceanography Centre	United Kingdom (of Great Britain and
73	29	23			Replace "main nutrients" with "macronutrients"	Accepted	Stephanie Henson	National Oceanography Centre	United Kingdom (of Great Britain and
77	29	26			Replace "speed up" with "stimulate"	Accepted	Stephanie Henson	National Oceanography Centre	United Kingdom (of Great Britain and
79	29	27	29	29	The carbon sequestration potential of nutrient fertilisation is not clear - cross-reference with SROCC 5.5.1 and WG1 5.6.2.2.2	Noted	Stephanie Henson	National Oceanography Centre	United Kingdom (of Great Britain and
1647	29	28			needs cite for manufactured alkalinity eg planetary hydrogen process	Noted	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and
22145	29	32	29	32	On the statement "on fertilisation for fish stock enhancement." we suggest to complete, "for instance, as naturally occurs in eastern boundary current systems, which sustain large small pelagics stocks due (in part) to the abundance of nutrients brought by upwelling." e.g.: Bertrand A, Lengaigne M, Takahashi K, et al (2020) El Niño Southern Oscillation (ENSO) effects on fisheries and aquaculture. Rome: Food and Agriculture Organization of the United Nations Chavez FP, Bertrand A, Guevara-Carrasco R, et al (2008) The northern Humboldt Current System: Brief history, present status and a view towards the future. Prog Oceanogr 79:95–105. https://doi.org/10.1016/j.pocean.2008.10.012	Taken into account: partially added	Government of France	Ministère de la Transition écologique et solidaire	France
1645	29	33			iron fertilization would have to cause widespread benthic anoxia to work.huge damage with dangerous potential consequences	Noted: side effects are discussed	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and
81	29	34	29	47	Please check SROCC 5.5.1.2.4 and WG1 5.6.2.2.3 for consistency	Noted	Stephanie Henson	National Oceanography Centre	United Kingdom (of Great Britain and
65245	29	34	29	39	Minerals do not necessarily have to be dissolved on land as it is stated here. They can be dissolved on the coasts, where wave energy accelerates comminution and generate more surface area of mineral (e.g. olivine) ready to dissolve and release alkalinity directly in the ocean. This summarizes a negative emission technology known as "coastal enhanced weathering", which should be mentioned here. Coastal enhanced weathering was described, modeled and tested experimentally in two papers (Meysman, F.J. and Montserrat, F. (2017) Biol Lett 13.; Montserrat, F., Renforth, P., Hartmann, J., Leermakers, M., Knops, P. and Meysman, F.J. (2017) Environ Sci Technol 51, 3960-3972.) and should be cited in this paragraph as an example of potential enhanced weathering solution. In the current version of the report, both studies (Montserrat and Meysman 2017, Meysman et al. 2017) simply appear between p12-31 l.46 and p12-32 l.2 to support that dissolution by-products other than alkalinity constituents released in the ocean upon weathering. Both studies actually show substantial alkalinity release in seawater upon olivine dissolution. Citing these studies just in the context of risks and impacts and not mention coastal enhanced weathering as a manner of sequestrating CO2 seems unfair.	Taken into account: partially added into the text	Olivier Sulpis	Universiteit Utrecht	Netherlands
65595	30	3	30	7	Should review the sentence about the definition of blue carbon. Suggestion "The term was used originally to refer to biological carbon sequestration in all marine ecosystems but it has also been currently (and increasingly) used to address carbon removal associated with rooted vegetation in the coastal zone, such as tidal marshes, mangroves and seagrasses."	Taken into account: suggested revision is accepted with modification, combined with comment 70557	Mônica M. C. Muelbert	UNIFESP	Brazil
70557	30	3	30	7	Please note that the glossary - Annex A states the following for Blue carbon: 'All biologically-driven carbon fluxes and storage in marine systems that are amenable to management can be considered as blue carbon. ...There is current debate regarding the application of the blue carbon concept to other coastal and non-coastal processes and ecosystems, including the open ocean.'	Taken into account: suggested revision is accepted with modification, combined with comment 65595	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
65597	30	5	30	5	Check the reference to IPCC-SROCC. What does 5.5.1 mean? IPCC-SROCC should be added to the reference list on page 141 after line 23 as IPCCc, following IPCCa and IPCCb (1.5 °C and Land, respectively, on page 141 lines 18-23)	Accepted	Mônica M. C. Muelbert	UNIFESP	Brazil
43497	30	12	30	12	After 2014 Add "It should be mentioned that there is unsual increase of phytoplankton in south of Qeshm Island of the Iran Plateau (East of Persian Gulf) as well as Sea of Oman.(https://www.mehrnews.com/news/4927835)	Rejected: it is not a scientific publication. there is no evidence that this is due to an increase in iron and is not a seasonal phenomenon	sadegh zeyaeyan	Head of national center for forecasting and weather hazards management of Islamic Republic of Iran Meteorological Organization (IRIMO)	Iran

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50403	30	12	30	12	After 2014 Add "It should be mentioned that there is unsual increase of phytoplankton in south of Qeshm Island of the Iran Plateau (East of Persian Gulf) as well as Sea of Oman.(https://www.mehrnews.com/news/4927835)	Rejected: it is not a scientific publication. there is no evidence that this is due to an increase in iron and is not a seasonal phenomenon	Government of Iran	Islamic Republic of Iran Meteorological Organization (IRIMO)	Iran
70559	30	13	30	15	unclear	Taken into account: reformulated	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
8781	30	15	30	15	I suggest that more appropriate references than Buesseler et al. 2001 would be: Blain, S., Quéguiner, B., & Trull, T. (2008). The natural iron fertilization experiment KEOPS (KErguelen Ocean and Plateau compared Study): An overview. Deep-Sea Research Part II: Topical Studies in Oceanography, 55(5–7), 559–565. https:// doi.org/10.1016/j.dsr2.2008.01.002 Pollard, R. T., Salter, I., Sanders, R. J., Lucas, M. I., Moore, C. M., Mills, R. A., … Zubkov, M. V. (2009). Southern Ocean deep-water carbon export enhanced by natural iron fertilization. Nature, 457(7229), 577–580. https://doi.org/10.1038/ nature07716 Trull, T. W., Davies, D. M., Dehairs, F., Cavagna, A. J., Lasbleiz, M., Laurenceau-Cornec, E. C., … Blain, S. (2015). Chemometric perspectives on plankton community responses to natural iron fertilisation over and downstream of the Kerguelen Plateau in the Southern Ocean. Biogeosciences, 12(4), 1029–1056. https://doi.org/10.5194/bg-12-1029-2015	Taken into account: Buesseler et al. 2001 reference is removed, text is revised	Chris Vivian	Retired ex Cefas	United Kingdom (of Great Britain and Northern Ireland)
79207	30	16	30	26	Mention is made of specific proposals for generating alkalinity in marine environments, spanning a rather broad spectrum. The summary consists of the observation that the fate of the stored C is the same (HCO3 and CO3 ions). If these porposals are mentioned, then Montserrat et al 2017 and Meysman and Montserrat 2017 should be given due consideration in proposing the utilisation of the ultramafic alkaline mineral dunite or olivine in ground form and adding these to geophysically, geochemically or biologically active sediments in coastal and shelf seas. These papers do not stop at mere lab results, but offer additional discussion and evaluation of the proposed method and synthesise prior knowledge into a viable proposal, which is enjoying momentum up till date. To not include these in this report would be a misrepresentation of the state of the CDR field.	Taken into account: Enhanced weathering of silicate minerals such as olivine is also a form of adding alkalinity to the ocean by placing olivine sand in coastal areas (Montserrat et al. 2017) Meysman and Montserrat 2017)	Francesc Montserrat	University of Amsterdam	Netherlands
74007	30	19	30	21	Enhanced weathering of silicate minerals such as olivine is a method with significant potential not specifically mentioned here. This is a form of adding alkalinity to the ocean, doing so by placing olivine sand in coastal areas where the movement of water causes grain on grain collisions to accelerate dissolution. Numerous references elucidate the potential in terms of energy efficiency and scale; for example: Meysman, F. J. R., and F. Montserrat, 2017: Negative CO2 emissions via enhanced silicate weathering in coastal environments. Biol. Lett., 13, https://doi.org/10.1098/rsbl.2016.0905.; Montserrat, F., P. Renforth, J. Hartmann, M. Leermakers, P. Knops, and F. J. R. Meysman, 2017: Olivine Dissolution in Seawater: Implications for CO 2 Sequestration through Enhanced Weathering in Coastal Environments. Environ. Sci. Technol., 51, 3960–3972, https://doi.org/10.1021/acs.est.6b05942.	Taken into account: Enhanced weathering of silicate minerals such as olivine is also a form of adding alkalinity to the ocean by placing olivine sand in coastal areas (Montserrat et al. 2017) Meysman and Montserrat 2017)	Tom Green	Far Away Projects	United States of America
79191	30	24	30	26	Although few studies have explored the impact of OAE on (coastal) ocean ecosystems, especially the study of Albright et al (2016) has elucidated the effect on an entire ecosystem and definitively points in the direction of "desired" results. Here, the fact that few studies have explored this alley, appears to mask the actual results and their implications. Please revise.	Taken into account: constrained field study quantifying the net calcification response of a coral reef flat to alkalinity enrichment (Albright et al. 2016)	Francesc Montserrat	University of Amsterdam	Netherlands
22147	30	25	30	26	Concerning the studies used here, we suggest it would be informative to describe in one sentence their main findings (eg positive vs negative impacts).	Noted: it is discussed in the part "Potential co-benefits and adverse effects"	Government of France	Ministère de la Transition écologique et solidaire	France
83	30	33	30	42	Consult SROCC 5.5.1 and up to date references: 10.3389/fmars.2018.00337 10.1038/d41586-019-01790-7 10.1088/1748-9326/aabf9f 10.1029/2019MS001787 10.1007/s40641-018-0104-3 and Keller (2019), Marine climate engineering in"Handbook on Marine Environment Protection: Science, Impacts and Sustainable Management"	Noted	Stephanie Henson	National Oceanography Centre	United Kingdom (of Great Britain and Northern Ireland)
12075	30	33	30	46	Suggest noting that OF modelling suggests that the location of OF will play a role in effectiveness - the subarctic Northern Pacific, Eastern Equatorial Pacific and Southern Ocean would be the most suitable locations for deployment, with the latter the most promising for net carbon sequestration – currently the text may be interpreted to mean geography is not an issue. See BOPP, L., RESPLANDY, L., ORR, J. C., DONEY, S. C., DUNNE, J. P., GEHLEN, M., VICHI, M. 2013. Multiple stressors of ocean ecosystems in the 21st century: Projections with CMIP5 models. Biogeosciences, 10(10), 6225–6245. https://doi.org/10.5194/bg-10-6225-2013	Taken into account: the issue and the reference is added	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
74009	30	33	30	34	Enhanced weathering of silicate minerals removes carbon dioxide primarily as inorganic carbon. This pathway could be noted here. References as above.	Noted	Tom Green	Far Away Projects	United States of America
85	30	36	30	36	replace "oxidised" with "remineralised"	Accepted	Stephanie Henson	National Oceanography Centre	United Kingdom (of Great Britain and
87	30	40	30	42	Also 10.1038/ncomms4304	Noted	Stephanie Henson	National Oceanography Centre	United Kingdom (of Great Britain and
89	30	43	31	2	Consult also 10.5194/esd-9-339-2018 10.1002/2017EF000659 10.1002/2016GL068576 10.1029/2018GL077847 10.1002/2017EF000620 10.1088/1748-9326/11/2/024007 and SROCC 5.5.1.2.4	Noted	Stephanie Henson	National Oceanography Centre	United Kingdom (of Great Britain and Northern Ireland)

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
79211	30	43	31	2	CEW is envisioned to have greater efficiency due the use of larger grain sizes, which translates to a lower (grinding) energy penalty. CEW is expected to have similar or higher efficiency than EW on land or OAE in open/deep ocean waters, due to lower energy input for grinding, as the proposed approach takes advantage hydrodynamic energy (bed shear stress, wave energy) causing communition of the primary material, by physical grain-grain abrasion processes.	Noted	Francesc Montserrat	University of Amsterdam	Netherlands
44045	30	45	31	2	It's worth adding that Caserini et al. (2021) show that global potential of CO2 removal from SL discharge by existing or new ships is estimated at several Gt/year, depending on the discharge rate. Caserini, S., Pagano, D., Campo, F., Abbá, A., Serena, D. M., Righi, D., Renforth P., Grosso M. (2021) Potential of maritime transport for ocean liming and atmospheric CO2 removal. Frontiers in Climate, in press	Taken into account: noted in the text	Stefano Caserini	Politecnico di Milano	Italy
12077	31	1	31	2	Only one estimate for OA removals suggested. This could be expanded to show the range of uncertainty e.g., suggest add Gonzaled and Lilyinas' analysis suggesting 3,500 Gt by 2100 at GONZÁLEZ MF, ILYINA T. Impacts of artificial ocean alkalinization on the carbon cycle and climate in Earth system simulations. Geophysical Research Letters. 2016 Jun 21;43(12):6493–502. Available from: http://dx.doi.org/10.1002/2016GL068576	Taken into account: reference is added, but figures are differenct. Gonzalez, Ilyna, (2016) show that addition of 114 Pmol of alkalinity to the surface ocean removes 940 GtC from the atmosphere and mitigates 1.5 K of global warming within this century.	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
91	31	3	31	7	Cross-check with SROCC 5.6.2.2.2 for consistency	Accepted	Stephanie Henson	National Oceanography Centre	United Kingdom (of Great Britain and
1601	31	3	31	7	There are a number of studies that quantify the potential of blue carbon sequestration; they should be included here to ensure parallel construction with the other ocean-based approaches, where the study quanitifies carbon sequestration potential in the text.	Taken into account: combined with comments 8783, 12079, 22149	Wil Burns	Institute for Carbon Removal Law & Policy, American University	United States of America
8783	31	3	31	4	The papers by Duarte et al. (2017) and Krause-Jense and Duarte (2016) should be taken into account here. Duarte et al. (2017) say "The 173 Tg C year −1 sequestered by wild seaweed is spread over the entire ocean, as most of this sequestration occurs in the deep sea, and the carbon supporting this flux is produced over the 3.5 million km2 occupied by seaweed". So Froelich et al. (2019) are suggesting a suitable area more than 10 times the area naturally occupied seaweeds. Is this credible?: Duarte, C.M. et al. (2017) Can Seaweed Farming Play a Role in Climate Change Mitigation and Adaptation? Frontiers in Marine Science, 4, 1-8. http://journal.frontiersin.org/article/10.3389/fmars.2017.00100/full Krause-Jensen, D., and Duarte, C. M. (2016). Substantial role of macroalgae in marine carbon sequestration. Nat. Geosci. 9, 737–742. doi: 10.1038/NGEO2790.	Taken into account: an area suitable for seaweeds production is discussed in the subsection "Marine biomass CDR options" based on Duarte, C.M. et al. (2017), Froehlich et al. (2019) ets. who suggests 48 million km2 suitable for farming seaweed	Chris Vivian	Retired ex Cefas	United Kingdom (of Great Britain and Northern Ireland)
12079	31	3	31	7	Suggest adding that macroalgal aquaculture may already account for the accumulation of ~0.8 Mt of organic carbon annually in the Asia-Pacific region SONDAK, C. PUT O.: BEARDALL, J BELLGROVE, A BOO, S et al., 2017. Carbon dioxide mitigation potential of seaweed aquaculture beds (SABs). Journal of Applied Phycology, 29, 2363-2373.	Taken into account: combined with other comments about BC potential	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
22149	31	3	31	7	Talking about how natural coastal ecosystems (mangroves, salt marshes...) are efficient and potentially important for future carbon sequestration is greatly needed in this part.	Noted	Government of France	Ministère de la Transition écologique et solidaire	France
93	31	8	31	11	Side effects include reduced productivity out of fertilised areas 10.5194/bg-7-4017-2010 10.1029/2009GL041961	Taken into account: combined with other comments below about OF side-effects	Stephanie Henson	National Oceanography Centre	United Kingdom (of Great Britain and
95	31	8	31	31	Table 5.A.2 in WG1 contains many details of side effects and adverse consequences	Taken into account: combined with other comments below about OF side-effects	Stephanie Henson	National Oceanography Centre	United Kingdom (of Great Britain and
44047	31	8	31	8	Although in the previous chapter 12.3.2.1 DACCS and 12.3.2.2 there are separate sections for Risk and Impacts and Co- benefits, her thete is a joint section with "Potential co-benefits and adverse effects". I strongly suggest two separate the two parts, as in the previous chapters.	Accepted	Stefano Caserini	Politecnico di Milano	Italy
44049	31	8	31	22	The report should better recognize the potentially significant benefits that OAE could have in counteracting ocean acidification, which is a very relevant issue (Honish et al., 2012) which is going to further increase in the future as the uptake of anthropogenic CO2 will continue (see i.e. Jiang et al. 2019 or AR6-WG1 ch. 5). I suggest citing in this chapter the modelling studies that demonstrate the potential of OAE to counteract the decreasing pH trend, such as Lenton et al. (2018) and Butenschön et al.(2021). I also suggest underlining that AOE and EW are the only CDR options that could ameliorate the effects of ocean acidification. It's worth remembering that no past event parallels future projections in terms of disrupting the balance of ocean carbonate chemistry due to the unprecedented rapidity of CO2 release currently taking place, and for this reason OAE should be studied and implemented also beyond its potential of carbon dioxide removal. Hönish B. et al (2012) The Geological Record of Ocean Acidification. Science, Vol. 335, Issue 6072, pp. 1058-1063 DOI: 10.1126/science.1208277 Jiang, LQ., Carter, B.R., Feely, R.A. et al. (2019). Surface ocean pH and buffer capacity: past, present and future. Nature Sci Rep 9, 18624 https://doi.org/10.1038/s41598-019-55039-4 Lenton, A., Matear, R. J., Keller, D. P., Scott, V., Vaughan, N. E. (2018) Assessing carbon dioxide removal through global and regional ocean alkalinization under high and low emission pathways. Earth Syst. Dynam., 9, 339-357, 2018. https://doi.org/10.5194/esd-9-339-2018 Butenschön M., Lovato T., Masina S., Caserini S. and Grosso M. (2021) Alkalinization scenarios in the Mediterranean sea for efficient removal of atmospheric CO2 and the mitigation of ocean acidification. Front. Clim. 3:614537. doi: 10.3389/fclim.2021.614537. In press	Taking into account: issue is discussed	Stefano Caserini	Politecnico di Milano	Italy

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
46201	31	8	31	8	Whether OF will lead to a potential increase in fish catches is highly speculative which should be stated. OF leads to a bottom up effect but it is not purposive to commercial fish species. The presented reference, as well as the additional reference, gives no causal relation between (commercial) fish species and OF. Consequently, this sentence is, in combination with the reference, too general in our opinion. There are better references (at least for the Great Lakes) to show a potential increase in commercial fish biomass (e.g. Peterman, R. M. 1991. Density-dependent marine processes in North Pacific salmonids: lessons for experimental design of large-scale manipulations of fish stocks. - ICES mar. Sei. Symp., 192: 69-77.) but also potential negative effects should be considered (e.g. https://doi.org/10.1098/rsta.2008.0139). However positive or negative effects on fish stocks remain speculative (DWR Wallace, CS Law, PW Boyd, Y Collos, P Croot, K Denman, PJ Lam, U Riebesell, S Takeda, & P Williamson: 2010. Ocean Fertilization. A Scienti fic Summary for Policy Makers. IOC/UNESCO, Paris (IOC/BRO/2010/2)). Suggested alternative: "Co-benefits for OF include a potential increase in fish biomass and might lead to increase fish catches, but there can also be trade-offs. Generally knowledge on OF on fish catches is limited."	Taking into account: catching is changed to biomass	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
15643	31	9	31	9	"enhanced biological production" is correct based on the description on the reference.	Accepted	Suil Kang	Gwangju Institute of Science and Technology	Republic of Korea
16579	31	9	31	9	enhanced biological production is correct based on the description on the reference.	Accepted	Government of Republic of K	Korea Meteorological Administration (KMA)	Republic of Korea
97	31	12	31	22	Ocean alkalinisation only reduces ocean acidification in the surface (not deeper in the water) 10.1088/1748-9326/11/2/024007	Taking into account: issue is discussed	Stephanie Henson	National Oceanography Centre	United Kingdom (of Great Britain and
79197	31	12	31	13	acidification stress is put on all calcifying organisms, like scleractinian corals, shell-forming molluscs, and calcareous algae (e.g. coccolithophores, encrusting algae and calcareous leafy algae) not just "shell-forming" organisms. Please revise.	Accepted	Francesc Montserrat	University of Amsterdam	Netherlands
70561	31	16	31	16	The ocean - singular form is better suited.	Accepted	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
43369	31	17	31	22	From 2017, when the paper from Renforth and Henderson was written, until now, some other materials have been released that support the evidence that more research is needed in the area of marine ecosystem potential harm. Might be nice to get some there, e.g. "The potential environmental response to increasing ocean alkalinity for negative emissions" (Gore et al. 2018)	Taking into account: issue is discussed	BEATRIZ BECCARI BARRETO	Politecnico di Milano	Brazil
79199	31	17	31	22	This seems strange: why would there be a need for proof that adding alkalinity (i.e. reversing acidification) is environmentally harmless ? Increasing seawater alkalinity in and of itself, is the concept which would reverse the current anthropogenic disturbance to the global carbon cycle. Therefore, by reversing the "harm" of acidification, it should not need any proof that that is harmless. Proving that reversing the incurred acidity is not harmful to the marine environment, seems to put the onus on the wrong side. It implies that the process of increasing atmospheric and seawater CO2 during the last 150 years is the baseline, whereas that is -still- the anomaly. This appears a faulty thought process, and really needs to be revised ! There is, however, a clear need to provide evidence that the by-products of processes that deliver alkalinity (e.g. EW, OAE) do not pose any environmental harm. This is exactly hte intention of (applied) research performed on the field of CEW, between academic institutions, corporate partners in relevant industries and internationally operating NGOs. The field of CEW, as well as any other field researching any of the other CDR methods, would greatly benefit from being given due consideration in this AR.	Taken into account: agree, "harm" of acidification is not discussed any more	Francesc Montserrat	University of Amsterdam	Netherlands
99	31	23	31	31	Refer to WG1 5.6.2.2.2 for up to date references	Taken into account: combined with other comments below about BC co-benefits and side effects	Stephanie Henson	National Oceanography Centre	United Kingdom (of Great Britain and
12081	31	23	31	31	Suggest including reference to the use of macroalgae in fuels and the related benefits - N'Yeurt et al., (2012), for example, has demonstrated that if 9% of the oceans were converted to macroalgal aquaculture they could potentially generate 12 Gt per annum of bio digested methane. This could be burned as a substitute for natural gas. The biomass involved would capture 19 Gt of CO_2 and the CO_2 produced by burning the methane would be captured and sequestrated (also discussed in GESAMP, 2019) N'YEURT, A. D. R. C., DAVID P.: CAPRON, MARK E.: STEWART, JIM R.: HASAN, MOHAMMED A. 2012. Negative carbon via Ocean Afforestation. Process Safety and Environmental Protection, 90, 467-474	Taken into account: information is considered in the co-benefits discussion	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
57793	31	23	31	31	""Globally, the total carbon sequestration rates are estimated in the range of 0.02-0.08 Gt yr-1 CO2 for different species (Wilcox et al., 2017; National Academies of Sciences, 2019)."" This sentence underestimates the potential for blue carbon sinks. Suggest appending the following: ""Larger sequestration is likely possible with kelp reforestation or further development of offshore seaweed mariculture.""	Taken into account: information is considered in the potentials discussion	Government of United State	U.S. Department of State	United States of America
65489	31	24	32	30	Is there any particular reason why the ocean CDR (discussed above) is not included in this section? If so, could you explain? Table 12.5 is helpful, could it also include ocean based CDR, if not can that be explained/justified?	Accepted: ocean CDR is added	Albertine Pegrum-Haram	European Climate Foundation	United Kingdom (of Great Britain and Northern Ireland)
22151	31	25	31	27	The sentence "The conservation and restoration of coastal ecosystems, which will lead to increased carbon sequestration, is also essential for the preservation of basic ecosystem services" would be more explicit with the following addition: "... basic ecosystem services such as resource provision and coastal protection, ..."	Rejected: resource provision is not CDR option.	Government of France	Ministère de la Transition écologique et solidaire	France

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
79201	31	27	31	29	Seaweed cultivation for re-utilisation is not a valid Blue Carbon or CDR methodology, and as such does not have a place in this chapter, or even in this report. The mentioned processes and/or activities in which seaweeds are to be re-utilised, implies the C sequestered in their biomass is to be respired again, and thus will end up as atmospheric CO2. Only if the sequestered C is locked away as e.g. building materials, construciton fibers or the like, are seaweeds candidates for CDR. In all other cases, such as those mentioned here, seaweeds do not qualify for CDR purposes, and this non-qualification should be explicitly emphasised in this context.	Accepted: this is explaind in Potential section. Also this sentence is deleted from co-benefit section	Francesc Montserrat	University of Amsterdam	Netherlands
73913	31	30	31	31	It is likely to be a difference between 'National Academies of Sciences (in the in-text citation)' and 'National Academies of Sciences Engineering and Medicine (in the References)'.	Rejected: this is the same reference	Raehyun KIM	National Institute of Forest Science	Republic of Korea
101	31	32	32	6	Table 5.A.2 in WG1 contains many details of side effects and adverse consequences	Taken into account: WGI analysis is considered and integrated	Stephanie Henson	National Oceanography Centre	United Kingdom (of Great Britain and
22153	31	32	31	32	This comment also applies to the other solutions mentioned in this chapter: This "Risks and impacts" section describes several significant consequences of the mentioned "solution" on ecosystems, with expectedly important impacts on ecosystem services and human life (ie generating bigger problems than provided solutions). This is problematic because of the split structure of the text, where the potential benefit of each tool is described separately from the risks. It means that the reader can stop after reading about a potential solution without ever learning about the associated risks. To remedy to this, either the paragraph needs to be reorganized so that the potentials and risks of each tool are provided together (for example for OF, then OA, then Blue carbon ,etc.), or the respective solutions paragraphs should include some early reference to the potential risks, eg using a sentence in the for of "... but see potential risks below (section Risks and impacts p. 31)".	Rejected: there is no space to discuss separetly each ocean-based CDR method	Government of France	Ministère de la Transition écologique et solidaire	France
22155	31	32	31	32	Concerning OF, - Some of the possible side effects include, changes in phytoplankton species which will have an affect on the food web, increased fish stocks, harmful algal blooms, more jellyfish, production of nitrous oxide and methane and nutrient depletion elsewhere when fertilized waters resurface. - "We can disrupt the marine ecosystem by iron seeding. This iron will induce a generous growth in all kinds of phytoplankton, even in ones belonging to genus Pseudonitzschia that produces toxic levels of domoic acid. This acid causes death in various aquatic animals due to which, an unbalance in the ecology of oceans occurs. Secondly, the iron fertilization will lead to lower oxygen levels in the deep seas. When the algae will sink deep in the sea the micro-organism will consume the oxygen of the ocean to raven the algae. Even deep-sea animals will consume oxygen. Therefore, large blooms of planktons would deteriorate the level of oxygen."	Taking into account: potential decrease of oxydation level is discuss in the sidw-effects section	Government of France	Ministère de la Transition écologique et solidaire	France
46203	31	32	32	21	Please position the risks and impacts and costs of Ocean Alkalinity before the potential co-benefits and adverse effects as you did for the previous CDR options. A uniform sequence makes it easier for the reader to classify and compare the facts.	Accepted: done	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
12085	31	38	31	39	Suggest noting that the identified potential for geopolitical conflict, alteration of marine resources, effects on food supply and difficulties of attribution highlights the importance of governance work about the techniques addressed.	Taken into account: these issues are discussed in section 12.7 Polycentric governance of carbon dioxide removal, food systems and land-based mitigation. "Geopolitical conflict" is removed from this section	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
22157	31	38	31	39	We recommand to clarify this sentence, the link with geopolitical conflict is unclear, as it is not in the same category of risks as the others listed	Accepted: these issues are discussed in section 12.7 Polycentric governance of carbon dioxide removal, food systems and land-based mitigation. "Geopolitical conflict" is removed from this section	Government of France	Ministère de la Transition écologique et solidaire	France
15645	31	39	31	39	The reference (GESAMP 2019) should be added at the end of the setence because that sentence is from the reference.	Accepted: the sentence is revised but reference is added	Suil Kang	Gwangju Institute of Science and Technology	Republic of Korea
16581	31	39	31	39	The reference (GESAMP 2019) should be added at the end of the setence because that sentence is from the reference.	Accepted: the sentence is revised but reference is added	Government of Republic of K	Korea Meteorological Administration (KMA)	Republic of Korea
22159	31	40	31	40	Concerning OA, - more extreme carbonate chemistry perturbations due to “non-equilibrated OAE” at perturbation hotspots may transiently occur and these hotspots will also have a higher potential to affect marine biota. (Hovortka et al. 2019) - There is still important knowledge gaps around OA	Noted: issue is added, but reference is not found	Government of France	Ministère de la Transition écologique et solidaire	France
57795	31	40	32	6	"It is very difficult to determine which emissions and removals are natural and which are anthropogenic for blue carbon approaches." Consider adding: "... ; however, methodologies are presently under development to track and verify carbon sequestration in the deep ocean from seaweed cultivation."	Rejected: not references	Government of United State	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
79193	31	46	32	2	It is stated that the ecological consequences of OAE by alkaline mineral addition (effectively CEW) remain poorly understood. In both the papers mentioned (Montserrat et al 2017 and Meysman and Montserrat 2017) the general and conceivable consequences are well described. Environmental mpacts are not discussed in detail or made explicit, but appear well constrained, especially based on well-constrained system knowledge. With the addition of the paper by Bach et al (2019), the consequences have been constrained even better. It would be good to give the combination of these evaluations due consideration, or at least change the denomination "poorly understood" to something that suggest an increasing understanding, thereby acknowledging the progress (in terms of knowlegde finding) which has been made.	Accepted: section is revised	Francesc Montserrat	University of Amsterdam	Netherlands
22161	32	2	32	6	In the "Potential co-benefits and adverse effects" section on blue carbon, the risks are mentioned but not the co-benefits .	Taking into account: benefits section is separated	Government of France	Ministère de la Transition écologique et solidaire	France
79195	32	4	32	6	Typical Blue Carbon schemes should be targeting wet, vegetated ecosystems and consists of a mix of restoration, conservation and areal increase. While the Carbon sequestration potential of such ecosystems can be used in investment vehicles to make it worthwhile investing, the entire "package" should consist of natural capital enhancement, safeguarding the resilience of such ecosystems and the ecosystem services they provde. In addition, engineering interventions can decrease the sensitivity of such ecosystems to (further) disturbances. This should be mentioned. Further, the last sentence of this paragraph stands on its own, without any further discussion or reference. Revise or remove.	Taking into account: section is revised	Francesc Montserrat	University of Amsterdam	Netherlands
103	32	7	32	23	The technical feasibility of nutrient fertilisation and ocean alkalinisation is likely low, as most of the studies cited (which rely on model simulations of CDR approaches) assume that iron/nitrate/olivine etc. can be applied over the entire ocean, all the time, which is clearly technically unfeasible	Taking into account: feasibility is disscussed separetely in section 12.3.2.4 Feasibility assessment	Stephanie Henson	National Oceanography Centre	United Kingdom (of Great Britain and Northern Ireland)
22163	32	7	32	7	No mention of costs for blue carbon as opposed to fertilization or alkalinity. We sugest to complement this part	Accepted: added	Government of France	Ministère de la Transition écologique et solidaire	France
75715	32	15	32	19	An initial techno-economic assessment of coastal enhanced weathering indicated a cost of carbon capture of $23 / tonne (Stopnitzky et al, 2021, manuscript submitted to IPCC). Coastal enhanced weathering uses wave and current energy to break down the olivine, resulting in the possibility of using larger grain sizes and therefore lower communition costs.	Taking into account: section is revised	Tom Green	Far Away Projects	United States of America
46205	32	25	32	35	The lack of evidence to assess sociocultural and environmental and institutional feasibility puts the implementation potential into perspective. Please highlight this research gap and that a good performance in technological dimension alone is insufficient.	Noted: discussed in section 12.3.3 Governance and Policymaking	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
44051	32	32	34	1	Table 12.5 is not clear at all. The explanation with colours, LoA and LoE is very difficult to follow. There are too much NA and NE. Furthermore, this table doesn not consider Ocean-based approaches (12.3.2.3), and this is a relevant limitation. I suggest deleting it, to save space, and eventually add additional comments to the text on the feasibility of the different options.	Noted: feasibility assessment framefork is presented in Chapter 6 (reference is provided befor the table). Presentation format is revised and ocean-based approaches are added	Stefano Caserini	Politecnico di Milano	Italy
70563	32	32	34	1	on what bases has this table 12.5 been built? Is there a means of introducing references to some literature?	Noted: feasibility assessment framefork is presented in Chapter 6 (reference is provided befor the table). Presentation format is revised and literature references are also included	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
79205	32	32	34	1	Once again, because CEW or OAE using alkaline minerals is not discussed in more detail, there is potential missed in this table, in terms of feasibility and/or cost per ton CO2 (deploying alkaline minerals in large-scale sediment management [beach nourishments, land reclamation, dredging, etc] may yield a very low cost per ton). At least, give the full spectrum of EW (and not only land-based) due consideration. In the OAE section, it is recognised that OAE has three origins, of which one is effectively EW. Although EW is mainly considered a terrestrial process, its final destination is arguably the ocean, and thus the separation between EW and OAE seems artificial at best, and harmful for its complete understanding at worst. Please consider a revision of the processes and their domains.	Taken into account: CEW ant its application to OAE is disscussed in the text	Francesc Montserrat	University of Amsterdam	Netherlands
18493	33	1	33	1	Please clarify units, should Gt be GtCo2 pa? 2nd row of table	Accepted. Table entries revised	Government of United Kingd	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
18495	33	1	33	1	Shouldn't energy requirements be mentioned in this table? Probably as a geophysical resource, or as a constraint on technological scalability. Table 12.5	Accepted. Table entries revised	Government of United Kingd	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
295	34	2	36	40	I am missing, but maybe wrong to address this here: A/R - The increase in use of wood products from A/R for bioenergy causes a likely, at least for the US, a deficite in nutrient supply by natural weathering (Oliveira-Garcia et al., 2018). It was proposed that application of rock products (enhanced weathering) might resupply the observed gap (Oliveira-Garcia et al., 2020). In addition the application of rock products could help to increase water holding capacity in certain areas, and therefore the co-application of enhanced weathering and A/R has potential for co-benefits. If this should be in the section about A/R please move this comment to htere. Reference: 1) de Oliveira Garcia, W., Amann, T., & Hartmann, J. (2018). Increasing biomass demand enlarges negative forest nutrient budget areas in wood export regions. Scientific reports, 8(1), 1-7. 2) Oliveira Garcia, W. D., Amann, T., Hartmann, J., Karstens, K., Popp, A., Boysen, L. R., ... & Goll, D. (2020). Impacts of enhanced weathering on biomass production for negative emission technologies and soil hydrology. Biogeosciences, 17(7), 2107-2133.	Accepted-Implemented by adding a sentence to co benefits of A/R.	Jens Hartmann	Universität Hamburg	Germany
52573	34	2			Impact of BECCS on SDG should be included.	Accepted. Added a reference to demonstrarte impacts of BECCS on SDGs.	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
293	34	3	34	23	The co-deployment of CDR-options should include enhanced weathering with biochar with bioenergy plants. The rationale: I is not about to find the opimal method, but to maximaize the potential to bind CO2 or C per area. Therefore the method is not the only measure for the discusssion, but rather, how per land area the carbon binding potential can be optimized as discussed in Amann & Hartmann 2019. Citation: Amann, T., & Hartmann, J. (2019). Ideas and perspectives: Synergies from co-deployment of negative emission technologies. Biogeosciences, 16(15), 2949-2960.	Accepted. Implemented by adding sentence to show the effects of EW on A/R	Jens Hartmann	Universität Hamburg	Germany
80689	34	4	35	2	As alluded to by “negative effects,” the near-term carbon deficit from use of forest biomass for BECCS results in a carbon deficit for many years, generally several decades to a century—that is crucial for mitigating emissions and avoiding hitting the 1.5°C mark. Danielle Venton, Core Concept: Can bioenergy with carbon capture and storage make an impact?, PNAS (2016); Leturcq, P. (2020) GHG Displacement Factors of Harvested Wood Products: the Myth of Substitution, Nature Scientific Reports 10:1–9; Mary S. Booth, Not carbon neutral: Assessing the net emissions impact of residues burned for bioenergy, Environ. Res. Lett. 13 (21 February 2018); Sterman J. D., et al. (2018) Does replacing coal with wood lower CO2 emissions? Dynamic lifecycle analysis of wood bioenergy, Envtl. Research Letters 13(015007):1–10, 1 (“We simulate substitution of wood for coal in power generation, estimating the parameters governing NPP and other fluxes using data for forests in the eastern US and using published estimates for supply chain emissions. Because combustion and processing efficiencies for wood are less than coal, the immediate impact of substituting wood for coal is an increase in atmospheric CO2 relative to coal. The payback time for this carbon debt ranges from 44–104 years after clear-cut, depending on forest type—assuming the land remains forest. Surprisingly, replanting hardwood forests with fast-growing pine plantations raises the CO2 impact of wood because the equilibrium carbon density of plantations is lower than natural forests. Further, projected growth in wood harvest for bioenergy would increase atmospheric CO2 for at least a century because new carbon debt continuously exceeds NPP. Assuming biofuels are carbon neutral may worsen irreversible impacts of climate change before benefits accrue. Instead, explicit dynamic models should be used to assess the climate impacts of biofuels.”).	Noted. Chapter 7 has assessed the magnitude and temporal dimension of the claimed carbon deficit.	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America
80833	34	4	35	2	As alluded to by “negative effects,” the near-term carbon deficit from use of forest biomass for BECCS results in a carbon deficit for many years, generally several decades to a century—that is crucial for mitigating emissions and avoiding hitting the 1.5°C mark. Danielle Venton, Core Concept: Can bioenergy with carbon capture and storage make an impact?, PNAS (2016); Leturcq, P. (2020) GHG Displacement Factors of Harvested Wood Products: the Myth of Substitution, Nature Scientific Reports 10:1–9; Mary S. Booth, Not carbon neutral: Assessing the net emissions impact of residues burned for bioenergy, Environ. Res. Lett. 13 (21 February 2018); Sterman J. D., et al. (2018) Does replacing coal with wood lower CO2 emissions? Dynamic lifecycle analysis of wood bioenergy, Envtl. Research Letters 13(015007):1–10, 1 (“We simulate substitution of wood for coal in power generation, estimating the parameters governing NPP and other fluxes using data for forests in the eastern US and using published estimates for supply chain emissions. Because combustion and processing efficiencies for wood are less than coal, the immediate impact of substituting wood for coal is an increase in atmospheric CO2 relative to coal. The payback time for this carbon debt ranges from 44–104 years after clear-cut, depending on forest type—assuming the land remains forest. Surprisingly, replanting hardwood forests with fast-growing pine plantations raises the CO2 impact of wood because the equilibrium carbon density of plantations is lower than natural forests. Further, projected growth in wood harvest for bioenergy would increase atmospheric CO2 for at least a century because new carbon debt continuously exceeds NPP. Assuming biofuels are carbon neutral may worsen irreversible impacts of climate change before benefits accrue. Instead, explicit dynamic models should be used to assess the climate impacts of biofuels.”).	Noted. Chapter 7 has assessed the magnitude and temporal dimension of the claimed carbon deficit.	Gabrielle Dreyfus	Institute for Governance & Sustainable Development	United States of America
18497	34	8	34	8	"store the biogenic carbon permanently" It needs to be explained that only some of the biogenic carbon is stored permanently; that which forms diesel or biomethane is emitted back to the atmosphere, and there are emissions at numerous points in the supply chain too. The overall process might not even be carbon-negative.	Accepted. Clarification has been made to the sentence	Government of United Kingd	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
46207	34	8	34	8	Please correct: the permanence of storage is not total - leakage has to be accounted for, with leakage rates still posing a knowledge gap (see reference to Chapter 6 on next page and e.g. Monastersky, 2013 or Pawar et al., 2015). Comment: Especially when aiming at large-scale CO2-storage higher risks have to be accounted for as skilful storage selection and management will not be possible in all cases. Please replace "permanent" by "quasi-permanently". --- Monastersky, R., 2013, Seabed scars raise questions over carbon-storage plan. Nature 504, pp. 339–340. Pawar, R.J., Bromhal, G.S., Carey, J.W., Foxall, W., Korre, A., Ringrose, P.S., Tucker, O., Watson, M.N. White, J.A., 2015, Recent advances in risk assessment and risk management of geologic CO2 storage, International Journal of Greenhouse Gas Control 40, pp. 292–311. (Please consider this reference also in the paragraph on Risks on page 12-35-21 - 31.)	Accepted. ''quasi'' has been added to permanently	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
46209	34	18	34	20	What is described here should be commented upon prominently in the SPM: building climate policies on models with limited representation of CDR options should be avoided. Please mention also the risk of wrong conclusions from these models and the potential consequences these might have.	Noted; the potential of including this issue in the SPM will be discussed within the SPM author team and subject to future government comments on the draft SPM.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
47951	34	18	34	19	Recent insights on BECCS from EMF-33: https://link.springer.com/article/10.1007/s10584-020-02784-5, including costs: https://link.springer.com/article/10.1007/s10584-020-02799-y	Accepted. Reference added to the status of CDR	Matteo Muratori	NREL	United States of America
57797	34	21	34	21	Many regard soil carbon a separate pool that doesn't remove carbon from the atmophere but rather holds carbon from other sources. In this sense, it's more of an avoided emission. Authors should clarify how they are using the term "soil carbon sequestration".	Noted. Soil carbon sequestration is defined as land management changes which increase the soil carbon content resulting in a net removal of CO2 from the atmoshere	Government of United State	U.S. Department of State	United States of America
80219	34	22	35	1	This discussion of ncessary adaptation measures is missing a discussion of SRM to enhance policy relevance in context of a risk management decisionmaking framework. SRM should be analyzed in addition to CDR options. Suggestion: "Efforts should also be made to include SRM as a near-term option for climate stabilization, and to assess the costs and benefits associated with each mitigation measure."	Rejected. SRM is not the scope of chapter 12	Kelly Wanser	SilverLining	United States of America
12083	34	32	35	1	Table 12.5 suggests there may be evidence for public support for EW trials. I suggest this is an incomplete picture of the evidence. Whilst noting that what has been done has been focussed on Europe and the United States, research has suggested that enhanced weathering may be seen as being too slow a response to the climate crisis, although research in well controlled conditions is likely to be acceptable (Cox et al., 2020). Cox et al., (2020) also suggest that publics require greater clarity about the processes that would be involved and would wish to see evidence that the current scientific uncertainties can be resolved. Further, the study also indicates there may be a preference for the use of mine by-products for enhanced weathering rather than the sinking of new mines to access materials. COX, E., SPENCE, E. & PIDGEON, N. 2020. Incumbency, Trust and the Monsanto Effect: Stakeholder Discourses on Greenhouse Gas Removal. Environmental Values,29,197-220.	This comment refers to EW.There is no Line 32 on Page 34	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
15647	35	3	35	15	All the numbers should have the same decimal point first place. E.g. instead of 11.30 and 10.12, 11.3 and 10.1 should be used .	Accepted. Implemented	Suil Kang	Gwangju Institute of Science and Technology	Republic of Korea
16583	35	3	35	15	All the numbers should have the same decimal point first place. E.g. instead of 11.30 and 10.12, 11.3 and 10.1 should be used .	Accepted. Implemented	Government of Republic of K	Korea Meteorological Administration (KMA)	Republic of Korea
46211	35	3	35	7	Please rewrite: technical potential and implementation in models are mixed up here. Additionally, for quantification of the potentials a more reflected, methodology-based approach should be chosen when aiming at an assessment. COMMENT: As stated elsewhere in the report (e.g. page 34, this chapter) there are ongoing discussions especially on the BECCS potential under consideration: focussing on technical potential only is not appropriate. Taking into account sustainability considerations the maximum technical potential is to be sought close to the lower bound of the range given here (see Creutzig et al., 2018), thus being more than 20 times smaller than assumed here. --- Creutzig, F., Erb, K., Haberl, H., Hof, C., Hunsberger, C., Roe, S., 2021, Considering sustainability thresholds for BECCS in IPCC and biodiversity assessments, GCB Bioenergy, 2021;00:1–6., https://doi.org/10.1111/gcbb.12798.	Noted: The first section of the report refersto studies applying global Integrated Assessment Models (IAMs covering a wide range of potentialsbut later there is a sententnce which considers sustanability of technical issues by Fuss et al 2018	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
80691	35	3	35	15	The NET potentials for BECCS must account for the carbon deficit that results for several decades to a century when wood products are used. Danielle Venton, Core Concept: Can bioenergy with carbon capture and storage make an impact?, PNAS (2016); Leturcq, P. (2020) GHG Displacement Factors of Harvested Wood Products: the Myth of Substitution, Nature Scientific Reports 10:1–9; Mary S. Booth, Not carbon neutral: Assessing the net emissions impact of residues burned for bioenergy, Environ. Res. Lett. 13 (21 February 2018); Sterman J. D., et al. (2018) Does replacing coal with wood lower CO2 emissions? Dynamic lifecycle analysis of wood bioenergy, Envtl. Research Letters 13(015007):1–10, 1 ("We simulate substitution of wood for coal in power generation, estimating the parameters governing NPP and other fluxes using data for forests in the eastern US and using published estimates for supply chain emissions. Because combustion and processing efficiencies for wood are less than coal, the immediate impact of substituting wood for coal is an increase in atmospheric CO2 relative to coal. The payback time for this carbon debt ranges from 44–104 years after clear-cut, depending on forest type—assuming the land remains forest. Surprisingly, replanting hardwood forests with fast-growing pine plantations raises the CO2 impact of wood because the equilibrium carbon density of plantations is lower than natural forests. Further, projected growth in wood harvest for bioenergy would increase atmospheric CO2 for at least a century because new carbon debt continuously exceeds NPP. Assuming biofuels are carbon neutral may worsen irreversible impacts of climate change before benefits accrue. Instead, explicit dynamic models should be used to assess the climate impacts of biofuels."). Furthermore, even if BECCS were net zero or negative in the relevant next couple of decades, which it is not, large-scale biodiversity development requires vast land-use changes, which may have significant implications for food security and biodiversity. National Academies of Sciences, Engineering, and Medicine, Negative Emissions Technologies and Reliable Sequestration: A Research Agenda,10 (2019) ("Because food demand is expected to double by mid-century, repurposing a significant amount of current agricultural land to produce feedstocks for BECCS or for afforestation/reforestation might have a significant effect on food availability and food prices, with far-reaching effects on national security and biodiversity."). The IPCC Special Report on Climate Change and Land warns that high implementation of BECCS (11.3 GtCO2 yr-1 in 2050) could increase the population at risk of hunger by up to 150 million people and could have significant impacts on desertification and land degradation.	Noted. Chapter 12 has reflected the assessment by chapter 7 (and the underlying literature) in its assessment of CDR potentials.	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America
80835	35	3	35	15	The NET potentials for BECCS must account for the carbon deficit that results for several decades to a century when wood products are used. Danielle Venton, Core Concept: Can bioenergy with carbon capture and storage make an impact?, PNAS (2016); Leturcq, P. (2020) GHG Displacement Factors of Harvested Wood Products: the Myth of Substitution, Nature Scientific Reports 10:1–9; Mary S. Booth, Not carbon neutral: Assessing the net emissions impact of residues burned for bioenergy, Environ. Res. Lett. 13 (21 February 2018); Sterman J. D., et al. (2018) Does replacing coal with wood lower CO2 emissions? Dynamic lifecycle analysis of wood bioenergy, Envtl. Research Letters 13(015007):1–10, 1 ("We simulate substitution of wood for coal in power generation, estimating the parameters governing NPP and other fluxes using data for forests in the eastern US and using published estimates for supply chain emissions. Because combustion and processing efficiencies for wood are less than coal, the immediate impact of substituting wood for coal is an increase in atmospheric CO2 relative to coal. The payback time for this carbon debt ranges from 44–104 years after clear-cut, depending on forest type—assuming the land remains forest. Surprisingly, replanting hardwood forests with fast-growing pine plantations raises the CO2 impact of wood because the equilibrium carbon density of plantations is lower than natural forests. Further, projected growth in wood harvest for bioenergy would increase atmospheric CO2 for at least a century because new carbon debt continuously exceeds NPP. Assuming biofuels are carbon neutral may worsen irreversible impacts of climate change before benefits accrue. Instead, explicit dynamic models should be used to assess the climate impacts of biofuels."). Furthermore, even if BECCS were net zero or negative in the relevant next couple of decades, which it is not, large-scale biodiversity development requires vast land-use changes, which may have significant implications for food security and biodiversity. National Academies of Sciences, Engineering, and Medicine, Negative Emissions Technologies and Reliable Sequestration: A Research Agenda,10 (2019) ("Because food demand is expected to double by mid-century, repurposing a significant amount of current agricultural land to produce feedstocks for BECCS or for afforestation/reforestation might have a significant effect on food availability and food prices, with far-reaching effects on national security and biodiversity."). The IPCC Special Report on Climate Change and Land warns that high implementation of BECCS (11.3 GtCO2 yr-1 in 2050) could increase the population at risk of hunger by up to 150 million people and could have significant impacts on desertification and land degradation.	Noted. Chapter 12 has reflected the assessment by chapter 7 (and the underlying literature) in its assessment of CDR potentials.	Gabrielle Dreyfus	Institute for Governance & Sustainable Development	United States of America
22165	35	8	35	9	For this sentence, could you add the sections to refer to	Accepted-implementended	Government of France	Ministère de la Transition écologique et solidaire	France
22167	35	10	35	10	For the statement "Potential for biochar lies between 0.03–6.6 GtCO2-eq yr-1." could you add the sections to refer to	Accepted-Implementended	Government of France	Ministère de la Transition écologique et solidaire	France
22169	35	11	35	11	is NET an abbreviation? if not, we suggest to highlight the word with italics or bold font	Accepted-NET means Negative Emission Technologies	Government of France	Ministère de la Transition écologique et solidaire	France
48073	35	16	35	20	Regarding soil carbon sequestration, in Brazil the rapid adoption of no-till practice in agriculture is evidence of negative SOC costs. This excerpt should be reassessed by the authors taking into account existing evidence on the issue:	Noted. Refernce of the the evidence shouldto enable assess the cost	Marcelo moreira	UNICAMP - Agroicone	Brazil

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
50993	35	16	35	20	Regarding soil carbon sequestration, in Brazil the rapid adoption of no-till practice in agriculture is evidence of negative SOC costs. This excerpt should be reassessed by the authors taking into account existing evidence on the issue:	Noted. Refernce of the the evidence should enable to re assess the cost	Government of Brazil	Ministry of Foreign Affairs of Brazil	Brazil
57799	35	18	35	20	Abatement cost seems to be measured in tCO2 in this sentence. Shouldn't costs be a monetary measure (e.g., $US).	Accepted- Implemented by adding USD.	Government of United State	U.S. Department of State	United States of America
57801	35	21	35	31	Good to see acknowledgement of competing ecosystem services.	Noted	Government of United State	U.S. Department of State	United States of
54379	35	22			Add reference to: Cross-Chapter Box 5.1. Interactions between the carbon and water cycles, particularly with drought conditions. in Canadell JG, Moteiro et al. 2021. Global Carbon and other Biogeochemical Cycles and Feedbacks. WGI AR6.	Accepted-Implementended by adding refernce	Sabine Fuss	MCC Berlin	Germany
57803	35	24	35	26	Nice incorporation of albedo effects on some afforestation considerations; however, artifical regeneration itself has fossil fuel inputs via propagation, transport, planting, browse protection, and competition reduction. Are these elements incorporated into GHG mitigation potentials?	Noted. Artificial regeneration is not incled in the mitigation potential	Government of United State	U.S. Department of State	United States of America
1603	35	29	35	31	Biochar's risks are under-stated here. Large-scale deployment would likely require huge amounts of dedicated biomass to be grown, posing the same risks as AF/RF	Accepted-implemeted by adding a sentence which provides a rsk associated with inceased demand for dedicated biomass to be grown in oreder to incerease potential for biochar	Wil Burns	Institute for Carbon Removal Law & Policy, American University	United States of America
12087	35	36	35	37	Suggest adding 'consideration of long-term governance' to the sequestration risks and concerns regarding the permanence of carbon storage re A/R and soil carbon sequestration.	Accepted-Implemented	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
1605	35	39	35	39	Albedo changes can have VERY substantial impacts on AF/RF, especially in boreal regions, not sure that's mentioned, but should be in addition to implications for biochar deployment	Noted. We require a reference to include the suggested sentence	Wil Burns	Institute for Carbon Removal Law & Policy, American University	United States of America
1649	35	43			para paints a rosy picture of beccs. it will never be anything other than an economic burden,and will not compete with renewables on cost	Noted	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and
1651	35	45			beccs worsens air pollution through both stack emissions and biogenic aerosols compared to renewables	Noted	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and
22171	36	3	36	3	We recommand to complete this sentence with "as well as enabling reclamation of abandoned agricultural land" E.g.: van Asselen S, Verburg PH (2013) Land cover change or land-use intensification: Simulating land system change with a global-scale land change model. Glob Chang Biol 19:3648–3667. https://doi.org/10.1111/gcb.12331	Accepted- Implemented by adding a sentence	Government of France	Ministère de la Transition écologique et solidaire	France
65493	36	4	36	10	Would it be worth including here a discussion on what the main barriers to BECCS scale-up and implementation are? For example, a recent detailed case study (in Sweden) showed that though it is theoretically possible to achieve the envisaged scale of BECCS. This would take immediate action, and that the main barriers now are socio-economic, political and institutional - not technical. (Fuss et al., 2021, https://www.frontiersin.org/articles/10.3389/fenrg.2020.553400/full). A further discussion about how perception and politics influence implementation, and how acceptance is still lagging since the SR1.5 could be helpful. Maybe also mention that CDR approached that are perceived as natural seeming to galvanise more public support (Wolske et al., 2019) (though I understand data mass is low and preliminary it could be explained with limitations).	Accepted. Implemented by adding sentences.	Albertine Pegrum-Haram	European Climate Foundation	United Kingdom (of Great Britain and Northern Ireland)
79099	36	4	36	20	Potentially useful reference: Low, S., & Schäfer, S. (2020). Is bio-energy carbon capture and storage (BECCS) feasible? The contested authority of integrated assessment modeling. Energy Research & Social Science, 60, 101326. https://doi.org/10.1016/j.erss.2019.101326	Noted	Edith Juno	National Wildlife Federation	United States of America
22173	36	5	36	5	Concerning "two main areas", another factor likely to impede large-scale deployment is forgotten here: the availability of suitable sites for permanent geological storage	Noted-Reference would be helpful to address the issue raised	Government of France	Ministère de la Transition écologique et solidaire	France
1609	36	10	36	10	The discussion of biochar potential is too cursory. It fails to discuss the potential increased release of nitrous oxides and methane under some climates and soil conditions, and more recalcitrace of these GHGs under other circumstances.	Noted. Line 10 is not discussiong Biochar	Wil Burns	Institute for Carbon Removal Law & Policy, American University	United States of America
1607	36	11	36	11	A/R ARE the only CDR options instead of is, or make option singular.	Accepted and implemented	Wil Burns	Institute for Carbon Removal Law & Policy, American University	United States of America
1653	36	11			A/R not only commercial deployment (climeworks, nori)	Accepted and implemented	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and
12089	36	11	36	12	A/R is, strictly, not the only CDR option to have been deployed commercially – Carbon negative biochar is readily available in the market place -e.g., https://www.earthlybiochar.com/ and Climeworks are now commercially active - https://climeworks.com/	Accepted and implemented	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
70565	36	12	36	13	the coherence of these figures with those page 35 lines 8 to 14 is not clear	Accepted and implemented	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
12091	36	21	36	21	Suggest adding reference to Honegger, M. 2020 Addressing risks and trade-offs in governance in Florin, M.-V. (Ed.), International Governance of Climate Engineering. Information for policymakers (2020), Lausanne: EPFL International Risk Governance Center (IRGC). DOI:10.5075/epfl-irgc-277726	Accepted- Implemented by adding reference	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
77639	36	21	36	37	This section could note that some land based options are riskeir than others.Factoring in permnence and reducing the risk of premature release of GHG to the atmosphere requires priority be given to improved protection and conservation mangement of primary forests - followed by encourgaging ecologically based restoration such as allowing secondary natural forests to keep growing, buffering and reconnecting even small patches of primary (old growth) forests and strategically shifting wood supply to purpose planted trees in agro ecological systems. There are very clear differences in risk of premature release of carbon to the atmosphere related to ecosystem condition (or integrity). Note that natural patterns of biodiversity play a key functional role in ecosystem integrity and stability and thus reducing the risk of loss from pests, disease, drought and fire...risks that are and will continue, to increase with already locked in climate change. (Mackey et al, Mitigation and Adaptation Strategies for Global Change, 2020; Intact forests in the United States: proforestation mitigates climate change and serves the greatest good, Moomaw et al Frontiers for Global Change 2019; The Nexus Report: Nature Based Solutions to the Biodiversity and Climate Crises, Barber C.V, Petersen R., Young V, Mackey B, Kormos C, 2020; IUCN Policy on Primary Forests including Intact Forest landscapes, 2020; Integrating forest management across the landscape: a three pillar framework, Morgan, Cadman & Mackey, Journal of Environmental Planning and Management 2020)	Accepted-Implemented by adding a sentence	Virginia Young	Australian Rainforest Conservation Society	Australia
70567	36	23	36	28	which of (i) or (ii) is the more efficient? There is some literature dealing with this issue and giving diverging answers.For example: Roux A., Dhôte J.-F. (Coordinateurs), Achat D., Bastick C., Colin A., Bailly A., Bastien J.-C., Berthelot A., Bréda N., Caurla S., Carnus J.-M., Gardiner B., Jactel H., Leban J.-M., Lobianco A., Loustau D., Meredieu C., Marçais B., Martel S., Moisy C., Pâques L., Picart-Deshors D., Rigolot E., Saint-André L., Schmitt B. (2017). Quel rôle pour les forêts et la filière forêt-bois françaises dans l'atténuation du changement climatique? Une étude des freins et leviers forestiers à l'horizon 2050. Rapport d'étude pour le Ministère de l'agriculture et de l'alimentation, INRA et IGN, 101 p. + 230 p. (annexes). versus Du Bus de Warnaffe, G., & Angerand, S. (2020). GESTION FORESTIÈRE ET CHANGEMENT CLIMATIQUE UNE NOUVELLE APPROCHE DE LA STRATÉGIE NATIONALE D'ATTÉNUATION. https://sosforetfrance.org/wp-content/uploads/2020/02/rapport-webforet-climat-fern-canopee-at.pdf	Noted	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
22175	36	24	36	24	Concerning the statement "Land based mitigation strategies currently propose the use of forests", not only forests, but also the implantation of biomass crops in marginal lands. E.g.: Elbersen B, van Eupen M, Verzandvoort S, et al (2020) Deliverable 2.6 Methodological approaches to identify and map marginal land suitable for industrial crops in Europe	Noted	Government of France	Ministère de la Transition écologique et solidaire	France
22177	36	26	36	27	Forests are also a source of emissions offsets through REDD+ schemes. There are risks that the same CO2 capture potential is double-counted	Noted-Reference would be helpful to address the issue raised	Government of France	Ministère de la Transition écologique et solidaire	France
43247	36	28	36	37	Environmentally, the available studies show that (generally) a reusable packaging system has a lower environmental impact than single-use systems. Coelho, P. M., Corona, B., ten Klooster, R., & Worrell, E. (2020). Sustainability of reusable packaging-Current situation and trends. Resources, Conservation & Recycling: X, 100037.	Noted. Reference not compatible	Mariel Vilella	Zero Waste Europe/University of Manchester	United Kingdom (of Great Britain and Northern Ireland)
46213	36	28	36	28	Clarification required: What definition of 'land' is being used in this report? It is suggested to include such a definition. Please add this definition to the glossary.	Acceted. Land will be defined in Grosaly	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
57805	36	30	36	32	What is the evidence referred to here? Were the alternatives considered planting trees for mitigation vs. biodiversity, or planting trees for timber products (or another market oriented use) vs biodiversity?	Accepted-Clarified what type of evidence	Government of United State	U.S. Department of State	United States of America
65491	36	30	36	32	Could you better explain the "evidence" for why mitigation is given priority over biodiversity, or please reference this statement.	Accepted- Implemented by providing a reference.	Albertine Pegrum-Haram	European Climate Foundation	United Kingdom (of Great Britain and Northern Ireland)
57807	36	40	38	1	The authors need to align Table 12.6 with the text -- particularly with respect to "risks". For example, in the table the risk associated with EW is "mining impacts". In the text they are air quality, biodiversity, and significant energy requirement (up to 6% global electricity supply). For Ocean Enhancement and Fertilization, the risks are stated much stronger in the text (including potential drawbacks include subsurface ocean acidification, deoxygenation; altered regional meridional nutrient supply, fundamental alteration of food webs). So, generally, make sure the table cells are more representative of the text.	Table now alligned with text	Government of United State	U.S. Department of State	United States of America
1655	37	1			daccs location is constrained by energy and storage geology	Accepted. Table entries revised	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and
8157	37	1	38	1	Table 12.6: Please revise text in rows "BECCS" and "A / R" (page 38): these options can compete with all land-uses, not only "for land with biodiversity".	Accepted. Table entries revised	Joachim Rock	Thuenen-Institute of Forest Ecosystems	Germany
16609	37	1	37	1	Since the technology level of DACCS and BECCS varies widely from country to country, it is difficult to fill out the TRL level collectively.	Noted. We give range that covers this variability	Government of Republic of K	Korea Meteorological Administration (KMA)	Republic of Korea
22179	37	1	37	1	Table 12.6 : the "Status (TRL)" column should be more explicit - the legend should detail what TRL means and clarify better the level of uncertainty around each option	Accepted. Spelled out in caption	Government of France	Ministère de la Transition écologique et solidaire	France

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
29047	37	1	37	1	It is stated that DAC 'can be located anywhere'. This is not true, DAC has a certain degree and maybe a higher degree of freedom than other mitigation options such as CCS/BECCS but due to the high energy demand co-location with an (ideally low-carbon) energy source is required and for storage or utilisation of the captured CO2 further co-location might be favourable or required.	Accepted. Table entries revised	Jasmin Kemper	IEAGHG	United Kingdom (of Great Britain and Northern Ireland)
44053	37	1	38	1	Table 12.6 OAE – risk and impacts: I suggest changing “increase seawater pH and saturation states” with “local increase seawater pH and saturation states” since this is could be a local risk, but on a global scale the increase of seawater pH and saturation state that OAE can produce is a substantial co-benefit.	Accepted. Table entries revised	Stefano Caserini	Politecnico di Milano	Italy
44055	37	1	38	1	Table 12.6 OAE – Co-benefits: I suggest changing “Limiting ocean acidification” with “Limiting or counteracting the decrease in seawater pH and saturation states (ocean acidification), with benefits for marine ecosystems, biodiversity and calcifier planktic species.”	Accepted. Table entries revised	Stefano Caserini	Politecnico di Milano	Italy
46215	37	1	38	1	Table 12.6: Please revise text in rows "BECCS" and "A / R" (page 38): these options can compete with all land-uses, not only "for land with biodiversity".	Accepted. Table entries revised	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
57809	37	1	37	1	Afforestation/reforestation in this Table 12.6 doesn't include fossil fuel needed to propagate, establish, and protect artificial regeneration.	Rejected. Negligible	Government of United State	U.S. Department of State	United States of America
57811	37	1	37	2	In Table 12.6, under risks and impacts, consider feedbacks and tipping points where applicable for ocean fertilization, etc.	Accepted. Table entries revised	Government of United State	U.S. Department of State	United States of America
57813	37	1	38	1	Table 12.6 appears too optimistic. Perhaps this is a definitional issue associated with TRL levels.Technologies with a TRL of 7 or higher should have gone through pilot and demonstration scales and be pretty close to commercially viable. Technologies listed in that table are not commercially viable (without substantial subsidies) and many have not been through pilot scales and they are being listed as TRL 6 (e.g., BECCS is listed as TRL 5-6, though many would characterize it as much lower). This does not appear consistent with definitions in the literature.	Accepted. Table entries revised	Government of United State	U.S. Department of State	United States of America
57815	37	1	38	18	In Table 12.6, for BECCS and AF/RF, competition for land with biodiversity is a trade-off but omitted here is how these efforts can compete for lands for food production and thus exacerbate food insecurity. This should be added.	Accepted. Table entries revised	Government of United State	U.S. Department of State	United States of America
67257	37	1	38	1	Focussing on the small mitigation potential of blue carbon is technically correct but risks overlooking the importance of these ecosystems for biodiversity, and the importance of maintaining their existing carbon pools. Suggest focussing only on the mitigation benefits of restoration as a figure in the table, but also including a discussion on the importance of protecting marine ecosystems, including their role as a carbon reservoir. In policy discourse these two issues (mitigation as restoration, and the importance of protection) are often conflated (which can create problems e.g. related to carbon markets). This chapter would be a good opportunity to provide clarification.	Accepted. Table entries revised	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
70569	37	1	38	1	Table 12.6 - no need to place Blue crabon in inverted commas. What is the reason for it?	Accepted. Table entries revised	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
70571	37	1	38	1	Table 12.6 - for Blue crabon, 'no data' is indicated for cost. For blue carbon, there are three management approaches (each with different cost tags): preservation, restoration and creation. For valuing blue carbon, please see following sources: 'Loss of marshes, mangroves and seagrasses might imply economic costs of USD$6–42 billion annually [9].' - https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0126627; Monitoring and stewardship of blue carbon has costs but this ecosystem itself has a calculable value in societal benefit, and estimating this provides context against costs and shows return for conservation (Zarate-Barrera and Maldonado, 2015;Barnes et al., 2016); https://www.researchgate.net/publication/329396368_ECONOMIC_VALUE_OF_BLUE_CARBON_CHALLENGES_AND_OPPORTUNITIES_FOR_PORTUGUESE_COASTAL_HABITATS; https://www.frontiersin.org/articles/10.3389/fmars.2019.00331/full; https://link.springer.com/chapter/10.1007/978-3-319-17214-9_10; https://www.sciencedirect.com/science/article/pii/S0959378015000278 - Using conservative estimates of the social cost of carbon, we evaluate the carbon sequestration value flows over the entire basin to range between 127 and 1722 million €/year. Values per unit area range from −135 to 1000 €/km2 year, with the exclusive economic zone of some countries acting as net carbon sources. Whereas the contribution of physical processes can be either positive or negative, also depending on the properties of incoming Atlantic water, the contribution of biological processes to the marine “blue carbon” sequestration is always positive, and found to range between 100 to 1500 million €/year for the whole basin; https://www.sciencedirect.com/science/article/pii/S0308597X15003905 - Those considered “forest friends” who initially were helping to protect the mangroves from threats like grazing have been making a small amount mostly to offset travel costs which equated to roughly $45 USD per month. The project is now transitioning to a voluntary monitoring system with Mangrove Stewardship taken on by the community to care for their mangroves. Those doing the planting can usually work for about 4 hours a day during low tide and can make roughly $2.54 USD a day, or around $50-56 USD per month. Project managers on the project have been making about $120 USD per month and field officers making $225 USD per month [27]. Those raising seedlings are paid per sapling. Prices to date have ranged from 0.015 to 0.0375 USD per saplings, depending on the species (i.e., Avicennia, Ceriops,	Taken into account: used in blue carbon feasibility assessment	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
70573	37	1	38	1	Please indicate that of all the ocean CDR methods, blue carbon is the only one that is a 'no-regret' climate option. These ecosystems also provide essential benefits for climate change adaptation, including coastal protection and food security for many coastal communities.	Taken into account: used in blue carbon feasibility assessment and in the section text above	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
70575	37	1	38	1	Blue carbon - role in mitigation pathways states 'no data'. Many countries have included coastal ecosystem management in their national climate change mitigation activities, including under REDD+, NAMAs, NDCs and other mechanisms. https://www.iucn.org/resources/issues-briefs/blue-carbon, https://climatefocus.com/sites/default/files/20181203_Article%206%20and%20Coastal%20Blue%20Carbon.pdf	Accepted: used in blue carbon feasibility assessment and in Table 2.6	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
70577	37	1	38	1	Blue carbon - non-climatic benefits - yes, but also climatic benefits: it sequesters CO2. And if not protected, it will deliver climatic drawback.	Taken into account: used in blue carbon feasibility assessment and in the section text above	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
70579	37	1	38	1	For OF and acidification please see the following science sources that refute that https://www.resilience.org/stories/2019-07-14/why-ocean-acidification-could-make-some-geoengineering-schemes-irrelevant/ And recent research from the Massachusetts Institute of Technology suggests that there is a tipping point in acidification beyond which the process becomes self-reinforcing and could lead to a mass extinction.; https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3405667/ However, some ocean-based CDR approaches would (if deployed on a climatically significant scale) re-locate acidification from the upper ocean to the seafloor or elsewhere in the ocean interior. https://www-legacy.dge.carnegiescience.edu/labs/caldeiralab/Caldeira_research/Cao_Caldeira2.html It has been suggested that adding iron to the ocean could mitigate climate change and even ocean acidification. Using ocean carbon cycle model simulations, we show that ocean iron fertilization has negligible benefit to upper ocean chemistry, and would lead to greater acidification of the deep ocean. https://www.researchgate.net/publication/225423684_Can_ocean_iron_fertilization_mitigate_ocean_acidification - A globally sustained ocean iron fertilization could not diminish CO2 concentrations below 833ppm or reduce the mean surface ocean pH change to less than 0.38 units. This maximum of 0.06 unit mitigation in surface pH change by the end of this century is achieved at the cost of storing more anthropogenic CO2 in the ocean interior, furthering acidifying the deep-ocean. If the amount of net carbon storage in the deep ocean by iron fertilization produces an equivalent amount of emission credits, ocean iron fertilization further acidifies the deep ocean without conferring any chemical benefit to the surface ocean.	Noted: risk of deep ocean acidification is discussed in the text section on ocean fertilization	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
70581	37	1	38	1	Peatland and coastal wetland restoration - no cost is mentioned - Based on contract data from USDA's Wetlands Reserve Program, the costs of restoring and preserving a wetland range from $170 per acre in the western Dakotas, Montana, Arkansas, and Louisiana to $6,100 per acre in the major corn-producing areas and along the Northern Pacific Coast. https://www.ers.usda.gov/webdocs/publications/45347/51895_err183.pdf?v=855.5; http://www.edc.uri.edu/restoration/html/tech_sci/socio/costs.htm on average, about $16,000 to restore an acre of salt marsh; costs about $45,000 to restore an acre of seagrass...the total cost of a seagrass restoration project can be more than five times that amount, or about $245,000 per acre ; https://pubmed.ncbi.nlm.nih.gov/27509748/ - Findings showed that while the median and average reported costs for restoration of one hectare of marine coastal habitat were around US$80000 (2010) and US$1600000 (2010), respectively, the real total costs (median) are likely to be two to four times higher.; https://climate-adapt.eea.europa.eu/metadata/adaptation-options/restoration-and-management-of-coastal-wetlands - Total costs for an integrated project can nonetheless be high. For example, the Kruibeke project in the Scheldt estuary (BE) included modification of outer dikes, the construction of an inner set of dikes, consolidation of land and other activities: total costs have been about 100€ million for the 600 ha. site., TEEB has evaluated the monetary value of services of wetlands, notably the services provided by mangroves and tidal marshes (The Economics of Ecosystems and Biodiversity, TEEB, 2013). Although Europe does not have mangroves, these figures are relevant for tidal marshes, which are numerous in Europe. They estimate the value of service provided (water supply, raw materials, food, genetic, medical and ornamental resources) between US$ 44 and 8289 (33 – 6200€)/ha/year, the value of services regulated (air quality, climate, waterflow regulation, erosion prevention, nutrient cycle, water purification etc) to US$ 1914 to 135,361 (1430-101,200€)/ha/year. In particular, the moderation of extreme events is estimated between US$ 4 and US$ 9729 (3-7272€)/ha/year and erosion prevention between US$ 97 and 755 (72-565€)/ha/year. Both are counted among the most important services regulated by tidal marshes. Habitat services are estimated between US$ 27 to 68,795 (20-51400€)/ha/year and cultural services between US$ 10 and 2904/ha/year (2007 values). According to TEEB, coastal wetlands in the USA are estimated to currently provide US$23.2 billion per year in storm protection services alone.;	Taken into account: cost of costal blue carbon CDR options is discussed in the text section above	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
70583	37	1	38	1	Role in mitigation pathways states 'No data'. Many countries have included coastal ecosystem management in their national climate change mitigation activities, including under REDD+, NAMAs, NDCs and other mechanisms. https://www.iucn.org/resources/issues-briefs/blue-carbon, https://climatefocus.com/sites/default/files/20181203_Article%206%20and%20Coastal%20Blue%20Carbon.pdf	Accepted: used in blue carbon feasibility assessment and in Table 2.6	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
70585	37	1	38	1	Wetlands co-benefits - also protect the coastal communities from floods and shoreline erosion control (CC adaptation), filter our water, and provide habitat for fish and other wildlife.	Taken into account: used in OAE feasibility assessment	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
70587	37	1	38	1	OAE - challenges: mass of geochemical material required to make a significant local or regional effect on climate; drawbacks: little known about the ecological or environmental effects of adding alkalinity to the ocean, Attributing negative/ unintended effects impacts could be nontrivial, for example altered food-web interactions, Mineral extraction and transport would have sociopolitical effects. Transboundary issues. Trace elements within the minerals could effect marine resources, food security. Particles could accumulate on coastal areas, Transboundary issues. LP not covered at present, but could be. Concerns associated with mining: most approaches to ocean alkalinization require extensive mining and processing of raw materials, which raises local environmental and health concerns. Energy use: most approaches require large amounts of energy (e.g., for grinding rocks); co-benefits: protecting aquaculture and marine protected areas, including the Great Barrier Reef. GESAMP2019.	Taken into account: used in OAE feasibility assessment	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
70589	37	1	38		Please define TRL. What do the numbers mean? Reference to something?	Accepted. Spelled out in caption	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
78789	37	1	37	1	DACCS: the claim that DACCS would require water input is factually wrong and shall be corrected. Most DAC systems (all of the low-temperature solutions) can be run on zero water demand or even with water surplus. See details in Fasihi et al. (https://www.sciencedirect.com/science/article/pii/S0959652619307772). Such wrong claims shall be removed.	Accepted. Table entries revised.	Christian Breyer	LUT University	Finland
78791	37	1	37	1	DACCS: the cost range for DACCS is not fully inline with the full body of literature. See the cost results in Breyer et al. (https://www.cell.com/joule/fulltext/S2542-4351(19)30413-1), which would justify to set the lower limit to 50 USD/tCO2.	Accepted. Table entries revised.	Christian Breyer	LUT University	Finland
78793	37	1	37	1	DACCS: this statement is not correct and not covered by the body of literature. There is NO lack of low-cost and low-carbon energy, as ALL energy requirement can be based on practically unlimitedly scalable solar PV (see Breyer et al. https://www.cell.com/joule/fulltext/S2542-4351(19)30413-1) where it is also shown that cost levels below the mentioned ones are achievable, if based on low-cost scalable zero emission energy supply. Revision of this statement is required.	Accepted. Table entries revised.	Christian Breyer	LUT University	Finland
80693	37	1	38	1	Table 12.6; Bioenergy has adverse impacts on communities and ecosystems, including increased air pollution and damage to public health. Similar to burning coal, biomass burning releases pollutants detrimental to human health, including fine particulate matter (PM2.5). PM2.5 particulate pollution is especially harmful for children and adults with asthma and other respiratory and cardiac conditions. Increased PM2.5 levels are also associated with higher death rates from COVID-19. Sierra Club, The Conventional Biomass Industry in California (Last visited on 23 January 2021) ("[L]ike coal generation, solid fuel biomass generation releases criteria pollutants (including oxides of nitrogen (NOx), sulfur oxides (SOx), and fine particulate matter) that cause negative human health impacts, including asthma, heart disease, and premature death. In fact, biomass combustion is dirtier than coal generation with regards to particulate matter and NOx. Biomass generation proponents state that solid fuel facilities reduce pollution as these plants filter out 99 percent of PM 2.5 pollution and 95 percent of black carbon emissions. However, this claim refers to the most technologically advanced plants. The majority of the existing solid fuel, conventional biomass incineration facilities in California were built in the late 1980s and are not based on the most advanced technology. Furthermore, as many as 75 percent of conventional biomass facilities across the United States have been found not to be compliant with public health laws."); Pozzer A., et al. (2020) Regional and global contributions of air pollution to risk of death from COVID-19, CARDIOVASCULAR RESEARCH 116: 2247–2253, 2251 ("Our results suggest that air pollution is an important cofactor increasing the risk of mortality from COVID-19. This provides extra motivation for combining ambitious policies to reduce air pollution with measures to control the transmission of COVID-19."); Open letter by Allergy & Asthma Network, American Academy of Pediatrics, American Lung Association, American Public Health Association, Asthma and Allergy Foundation of America, National Association of County & City Health Officials, National Environmental Health Association and Physicians for Social Responsibility (13 September 2016) ("The undersigned public health, medical and nursing organizations urge you to oppose policies that would encourage or expand the use of biomass for electricity production. Biomass is far from "clean" – burning biomass creates air pollution that causes a sweeping array of health harms, from asthma attacks to cancer to heart attacks, resulting in emergency room visits, hospitalizations, and premature deaths."). In addition, deploying bioenergy at scale would threaten the cooling services provided by trees. See e.g.	Accepted. Table entries revised.	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America

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80837	37	1	38	1	Table 12.6; Bioenergy has adverse impacts on communities and ecosystems, including increased air pollution and damage to public health. Similar to burning coal, biomass burning releases pollutants detrimental to human health, including fine particulate matter (PM2.5). PM2.5 particulate pollution is especially harmful for children and adults with asthma and other respiratory and cardiac conditions. Increased PM2.5 levels are also associated with higher death rates from COVID-19. Sierra Club, The Conventional Biomass Industry in California (Last visited on 23 January 2021) ("[L]ike coal generation, solid fuel biomass generation releases criteria pollutants (including oxides of nitrogen (NOx), sulfur oxides (SOx), and fine particulate matter) that cause negative human health impacts, including asthma, heart disease, and premature death. In fact, biomass combustion is dirtier than coal generation with regards to particulate matter and NOx. Biomass generation proponents state that solid fuel facilities reduce pollution as these plants filter out 99 percent of PM 2.5 pollution and 95 percent of black carbon emissions. However, this claim refers to the most technologically advanced plants. The majority of the existing solid fuel, conventional biomass incineration facilities in California were built in the late 1980s and are not based on the most advanced technology. Furthermore, as many as 75 percent of conventional biomass facilities across the United States have been found not to be compliant with public health laws."); Pozzer A., et al. (2020) Regional and global contributions of air pollution to risk of death from COVID-19, CARDIOVASCULAR RESEARCH 116: 2247–2253, 2251 ("Our results suggest that air pollution is an important cofactor increasing the risk of mortality from COVID-19. This provides extra motivation for combining ambitious policies to reduce air pollution with measures to control the transmission of COVID-19."); Open letter by Allergy & Asthma Network, American Academy of Pediatrics, American Lung Association, American Public Health Association, Asthma and Allergy Foundation of America, National Association of County & City Health Officials, National Environmental Health Association and Physicians for Social Responsibility (13 September 2016) ("The undersigned public health, medical and nursing organizations urge you to oppose policies that would encourage or expand the use of biomass for electricity production. Biomass is far from "clean" – burning biomass creates air pollution that causes a sweeping array of health harms, from asthma attacks to cancer to heart attacks, resulting in emergency room visits, hospitalizations, and premature deaths."). In addition, deploying bioenergy at scale would threaten the cooling services provided by trees. See e.g.	Accepted. Table entries revised.	Gabrielle Dreyfus	Institute for Governance & Sustainable Development	United States of America
105	37				Table 12.6 : references should be added to each of the boxes in the table	Rejected. Section references are given where the evidence and references can be found	Stephanie Henson	National Oceanography Centre	United Kingdom (of Great Britain and
3939	37				Co-benefits stated for Enhanced weathering are highly uncertain and not true for all soils nor all climates, rather restricted to few of them.	Accepted. Table entries revised.	Rosa M Poch	ITPS and UdL	Spain
15649	37		37		For Co-benefits coumn of Enhanced weathering, "reduced pH" should be changed into "increased pH".	Accepted. Table entries revised.	Suil Kang	Gwangju Institute of Science and Technology	Republic of Korea
15651	37		37		Referring #2 comment, The role in mitigation pathways of Enhanced weathering, the main text showed that there is only one study for EW, but, in the table, it showes that a few IAMs. It should be clarified.	Accepted. Table entries revised.	Suil Kang	Gwangju Institute of Science and Technology	Republic of Korea
15653	37		37		For the Risk & Impacts of Ocean Alkalinity Enhancement, :Emergence of potential toxic species of diatoms stocks" corresponds to the Ocean fertilization, That part shpuld be moved to next box.	Accepted. Table entries revised.	Suil Kang	Gwangju Institute of Science and Technology	Republic of Korea
15655	37		37		For potential column, the decimal point first place should be unified. For BECCS "11" should be "11.3", For Afforestration/Reforestration, "10.5" should be "10.1".	Accepted. Table entries revised.	Suil Kang	Gwangju Institute of Science and Technology	Republic of Korea
16585	37		37		For Co-benefits coumn of Enhanced weathering, "reduced pH" should be changed into "increased pH".	Accepted. Table entries revised.	Government of Republic of K	Korea Meteorological Administration (KMA)	Republic of Korea
16587	37		37		Referring #2 comment, The role in mitigation pathways of Enhanced weathering, the main text showed that there is only one study for EW, but, in the table, it showes that a few IAMs. It should be clarified.	Accepted. Table entries revised.	Government of Republic of K	Korea Meteorological Administration (KMA)	Republic of Korea
16589	37		37		For the Risk & Impacts of Ocean Alkalinity Enhancement, :Emergence of potential toxic species of diatoms stocks" corresponds to the Ocean fertilization, That part shpuld be moved to next box.	Accepted. Table entries revised.	Government of Republic of K	Korea Meteorological Administration (KMA)	Republic of Korea
16591	37		37		For potential column, the decimal point first place should be unified. For BECCS "11" should be "11.3", For Afforestration/Reforestration, "10.5" should be "10.1".	Accepted. Table entries revised.	Government of Republic of K	Korea Meteorological Administration (KMA)	Republic of Korea
22181	37		37		Concerning the risk and impacts of "blue carbon", If well understood, for Blue Carbon the risks are essentially linked to their vulnerability. But isn't this an incentive to preserve and restore them?	Accepted. Table entries revised.	Government of France	Ministère de la Transition écologique et solidaire	France
52575	37		38		BECCS impacts should also include food	Accepted. Table entries revised.	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
1657	38	1			beccs air pollution benefits highly doubtful compared to renewables	Accepted. Table entries revised.	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and
29709	38	1	38	1	For "soil carbon sequestration" the cost interval here is given as 45 - 100 USD/tCO2, while the interval given elsewhere in the AG3 report is proposed as -45 to 100 USD/tCO2(that is, from negative to positive), for example in chapter 12 page 35 line 16-18, and in chapter 7 page 79 lines 4-6. Please go through the differences and include the appropriate number in the table.	Accepted. Table entries revised.	Government of Norway	Norwegian Environment Agency	Norway
57817	38	1	38	1	In Table 12.6, in the row labelled Afforestation/Reforestation, suggest renaming it to Afforestation/Reforestation of Land and Kelp Forests. Kelp reforestation is commercial today and is similar in scale and cost sequestration potential to terrestrial reforestation. The last column would then be: IAMs Chapter 7, Section 7.4 , Section 12.3.2.3.	Accepted. Table entries revised.	Government of United State	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
57819	38	1	39	1	In Table 12.6, under risks and impacts, the words "land and water" are repeated many times but are not helpful to readers. Land and water represent opportunities as well as risks. If this refers to potential competition, it is already stated under trade-offs. What other risks are referenced? Be more precise or give examples.	Accepted. Table entries revised.	Government of United State	U.S. Department of State	United States of America
11873	39	1	67	3	Miss the social and socio-economic aspects of malnutrition. Tends to exaggerate possibility to reduce GHG emissions and malnutrition due to farm practices.	**Rejected**. Quantitative estimates of the mitigation potential of farm practices are provided in Chapter 7; quantitative estimates of demand-side interventations are provided in Chapter 5. This section assesses technologie and policies of food system mitigation options.	The Royal Swedish Academy	Kung. Skogs-och Lantbruksakademien	Sweden
30571	39	3	40	4	It seems that 12.4.1 focuses too much on the topics such as unequal food distribution, health risks and employment issues, etc, which are not directly related to GHG emissions or mitigation. It would be better to put some paragraphs summarizing the whole section.	**Noted.** This sections gives a very condensed background of main food system aspects which are important to understand food system mitigation opportunities in their systemic context. However, to give a better framing of the section with regard to its objective (assessing food system mitigation options) we have re-structured the section, placing the reference to GHG mitigation as assessed in the IPCC SRCCL as second paragraph.	Government of Japan	Climate Change Division - Ministry of Foreign Affairs	Japan
57821	39	3	40	4	The first five paragraphs of Section 12.4 discuss food systems (including production, calory intake, malnutrition, and industry consolidation, among other topics) without explicitly mentioning climate change, GHGs, adaption, or mitigation. All of these things have implications for climate change policies, but the introduction should be reformatted to start with climate change then discuss how these topics are related. Perhaps the authors could start with paragraphs two and three on page 40, then begin the discussion at the start of the section (i.e., paragraphs one through five).	**Accepted**. We have re-structured the section, placing the reference to GHG mitigation as assessed in the IPCC SRCCL as second paragraph. This sets the scene better before describing the food system context and outlining the placing of this section in the overall report.	Government of United State	U.S. Department of State	United States of America
83675	39	3	39	3	It would be highly beneficial for policy makers and workers in the area of nutrition and agriculture if the IPCC would include the phrase "bioavailable nutrients/bioavailable nutrition" in the context of fundamental human needs. Bioavailability of nutrients can be the determining factor between nutrient sufficiency and nutrient insufficiency. While a certain diet can theoretically provide all of the essential nutrients in sufficient quantities (as per RDA), the quality of the diet would depend on the bioavailability of the nutrients contained within. Thus, like food, bioavailable nutrition is also a human right.	**Accepted.** Bio-availability of nutrients is an important aspect. The adjective 'bio-available' has been added, (i) in Section 12.4.1 "At least 340 million children under 5 years experience lack of vitamins or other essential bio-available nutrients, including almost 200 million suffering from stunting, wasting or overweight (UNICEF 2019). " and (ii) in Section 12.4.3.3 "Proteins from animal products are of high quality, while bio-availability of proteins in foods is influenced by several factors, including amino-acid composition, presence of anti-nutritional factors, and preparation method to improve bio-availability (Watford and Wu, 2011; Weindl et al. 2020; Semba et al.; 2021)."	Lakshmi Dave	Massey University	New Zealand
29559	39	16	39	18	This sentence is unclear. The words «concentrated on few crops» seems a bit out of place. We assume the point is that our food system is based on too few basic crops.	**Accepted.** Sentence modified.	Government of Norway	Norwegian Environment Agency	Norway
81727	39	18	39	18	Suggest amending this statement to say that "and there is a lack of access to sufficient nutrients from food such as fruit and vegetables in xyz scenario or meat in xyz scenario" The current statement "…nutrient-dense foods such as fruit and vegetables" can be misleading in two ways: 1) nutrient-density can be considered by different approaches and some approaches would indicate foods high in water (i.e. fruits and vegetables) are not nutrient-dense compared to other foods, and 2) the selection of two plant-sourced foods implies that animal sourced food are not nutrient-dense which is incorrect.[You can reference the study by Werner et al. 2014 (https://doi: 10.3402/fnr.v58.20687) which highlights that animal-sourced foods can have high nutritent dentsities and when considering in context of GHG emissions, they can be some of the most nutrient rich items per unit of GHGs emitted.]	**Accepted**. The sentence addresses two distinctive issues (i) lack of nutrient dense foods for (incl. animal-source foods) and (ii) too little consumption of fruit and vegetables. Thus the sentence has be clarified by deleting 'such as' and reads now "there is a lack of nutrient-dense foods, fruit and vegetables ". The sentence refers to current situation.	Government of New Zealand	Ministry for the Environment	New Zealand
22183	39	34	39	37	this sentence is missing the health issues associated with chemical inputs in agriculture. This can be mediated by adding the following to the sentence: "...food systems originate from toxic residuals from chemicals used in conventional, non-organic agriculture (Swanson et al. 2014), the use of antibiotics...". REF: Swanson NL, Leu A, Abrahamson J, Wallet B. 2014. Genetically engineered crops, glyphosate and the deterioration of health in the United States of America. Journal of Organic Systems 9(2):6-37.	**Accepted**. This aspect has already been captured in the previous sentence. However, that sentence has been modified to make the link to (also) agro-chemical more explicit refering to a recent review article on food safety. "[...] and contamination with toxic chemical substances used in agriculture and food processing, can lead to poisoning or chronic diseases (Gallo et al. 2020)"	Government of France	Ministère de la Transition écologique et solidaire	France
22185	39	34	39	37	We suggest to complement this sentence knowing that there is a toxicity risk for both humans and terrestrial ecosystems associated with fertilisation strategies (e.g. residual organic fertilisers bearing trace elements), use of phytosanitary substances (organic or metallic) and implantation strategies (e.g. cultivation close to roads or in contaminated sites) for crops, notably market vegetables. E.g.: Senesi GS, Baldassarre G, Senesi N, Radina B (1999) Trace element inputs into soils by anthropogenic activities and implications for human health. Chemosphere 39:343–377. https://doi.org/10.1016/S0045-6535(99)00115-0 Cambier P, Pot V, Mercier V, et al (2014) Impact of long-term organic residue recycling in agriculture on soil solution composition and trace metal leaching in soils. Sci Total Environ 499:560–573. https://doi.org/10.1016/j.scitotenv.2014.06.105	**Rejected**. The paper of Senesi et al. (1999) is too old and the paper of Cambier et al. (2014) refers to a specific study. Both paper address one of many possible trade-offs in agriculture that are beyond the level of detail this section can go into.	Government of France	Ministère de la Transition écologique et solidaire	France

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
86789	39	34	39	37	It is claimed that the use of antibiotics in livestock production systems and the occurrence of anti-microbial resistance creates health risks. But ths is not the case if used in accordance with multilateral science-based reccomendations (OIE Terrestral Code). In that regard, we suggest the following wording (added language in capital letters and deleted wording between parenthesis/brackets): "(Further h) Health risks from food systems MAY originate from the use of antibiotics mainly in livestock production systems NOT IN ACCORDANCE WITH OIE RECCOMENDATIONS and the occurrence of anti-microbial resistance in pathogens -ECDC et al. 2015; Bennani et al. 2020-, or zoonotic diseases such as BSE or COVID-19 -Vågsholm et al. 2020; Gan et al. 2020; Patterson et al. 2020-".	**Partially accepted.** We have included the word 'may' as suggested; this reflects in the evidence in the review paper of Bennani et al. (2020) therefore citation of OIE Terrestral Code is omitted.	Government of Argentina	Ministry of Environment and Sustainable development of Argentina	Argentina
57823	39	38	39	43	This chapter discusses consolidation within the food industry. The writing implies consolidation is undesirable from an economic or market perspective, but will it have a negative outcome for climate change? Is it possible that consolidation could lead to economies of scale which reduce transportation costs and food waste?	**Noted**. The text is descriptive and does not assess whether or not the consolidation has been positive or negative with respect to GHG emissions. A discussion on mitigation opportunities including food industry is provided in Section 12.4.3 and 12.4.5	Government of United State	U.S. Department of State	United States of America
83673	39	38	39	43	The highly consolidated modern food systems and the greater availability of highly processed foods have also contributed to an extensive loss of indigenous agriculture and food systems, thus leading to high levels of micronutrient deficiency (see FAO's work on indigenous food systems; also see Vogliano, C.; Raneri, J.E.; Maelaua, J.; Coad, J.; Wham, C.; Burlingame, B. Assessing Diet Quality of Indigenous Food Systems in Three Geographically Distinct Solomon Islands Sites (Melanesia, Pacific Islands). Nutrients 2021, 13, 30. https://doi.org/10.3390/nu13010030)	**Accepted.** Sentence modified and reference included.	Lakshmi Dave	Massey University	New Zealand
30573	39	41	39	43	The sentence says 'While agricultural producers contribute a higher proportion of GHG emissions compared with other actors in the supply chain, they have relatively little power to change the system (see Figure 12.6)'. It would be better to add some explanation for how to read Figure 12.6. In Figure 12.6, 'agricultural producers' seem to be 'primary food production' but have a strong power influence (red dotted line) on 'policy making', so the sentence does not seem consistent with the figure.	**Accepted.** Figure 12.6 required more explicatory text - for which no space is available. Therefore, it has been deleted for the FGG.	Government of Japan	Climate Change Division - Ministry of Foreign Affairs	Japan
46217	39	44	39	46	The sentence is unclear and confusing. If 27% of working people were employed by the mentioned sectors, how come in the next sentence we are speaking of 3% (in the developed countries) and 67% (in the developing countries). Sounds as if 27% is the average of 3% and 67%, which is not. We do neither understand these numbers nor the sense of the sentence. Perhaps “employment in these sectors” should read “employment *within* these sectors” to stress that this percentage refers to the people working on those sectors only? Or maybe the percentage of “unemployment” would be clearer instead.	**Accepted.** 27% is not the average, but the global value, taking into consideration that the total work force is not equally distributed between developing and developed countries. We have changed 'in these sectors' to 'within these sectors' as recommended. Also the numbers have been updated from the Worldbank data base.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
57825	40	5	40	17	Define "SRCCL" at first callout (Special Report on Climate Change and Land).	**Editorial**	Government of United State	U.S. Department of State	United States of
31225	40	13	40	14	Thank you for checking this sentence which does not seem to be completely accurate. Indeed, in these figures seem to miss the values concerning waste and loss. The reference to 2050, which is well present in the SRCCL, is missing.	**Accepted.** Sentence clarifed	Bruna Gaino	UCLouvain	Belgium
31227	40	13	40	13	The reference (Mbow et al. 2019b) contains an editorial error (reference to the 1.5° ratio instead of the SRCCL)	**Editorial**	Bruna Gaino	UCLouvain	Belgium
57827	40	41	40	43	At the end of this sentence is the only reference in the entire chapter to Figure 12.6. The flagged sentence makes a simple statement: "While agricultural producers contribute higher proportion of GHG emissions compared with other actors in the supply chain, they have relatively little power to change the system (see Figure 12.6)." Figure 12.6 is mind boggling in complexity and totally needless for the statement it is claimed to support. Authors should either delete Figure 12.6, or develop some substantive points using it. Finally, Table 12.7 makes the point much more simply and clearly.	**Accepted.** Figure 12.6 required more explicatory text - for which no space is available. Therefore, it has been deleted for the FGG.	Government of United State	U.S. Department of State	United States of America
28781	41	1	41	12	Figure 12.6 - Please clarify what the solid red Policy arrows represent. Is it the presence of policies or the strength or influence of existing policies? If it is about the influence of policies based on how strong they are, why isn't that just included as the influence of "Policy making" on the other stages actors, rather than having its own category?	**Accepted.** Figure 12.6 required more explicatory text - for which no space is available. Therefore, it has been deleted for the FGG.	Erin Biehl	Johns Hopkins Center for a Livable Future	United States of America
57829	41	15	41	25	Move to first paragraph of 12.4 (the top of the section introduction). At present the section takes a while to get to GHGs. With this paragraph up front, the rest follows more logically. Then here, simply restate the total (18.0 Gt CO2eq yr-1) and proceed to break it down by the categories below (energy, ...).	**Accepted**. The first sentence in the indicated paragraph has been moved to the introduction.	Government of United State	U.S. Department of State	United States of America
22187	41	16	41	25	It is important to note that the annual land use change emissions reported here correspond to the ongoing additional natural vegetation replacement for increasing food demand. This is not the GHG emissions footprint of food systems, which includes land use which changed in the past, but could revert to natural vegetation if the food demand decreased. Food systems GHG emissions footprint would allocate land use related GHG emissions to every area of land used for agriculture, including pastures based on the natural vegetation replaced.	**Accepted.** The sentence has been modified to make clear that the data presented by Crippa at al. (2021) are territorial-based.	Government of France	Ministère de la Transition écologique et solidaire	France
57831	41	22	41	25	The way the emissions are broken out by category is confusing. What does agriculture include that the following categories of land use, etc., do not? Are the emissions double counted (i.e., some of the agriculture emissions are attributable to land use or energy used to produce food)?	**Accepted.** Clarified that the categorization was done according to IPCC classifications.	Government of United State	U.S. Department of State	United States of America
1445	41		41		figure 12.6 has low quality	**Accepted.** Figure 12.6 required more explicatory text - for which no space is available. Therefore, it has been deleted for the FGG.	Hamideh Dalaei	climatologist at Islamic Republic of IRAN Meteorological Organisation	Iran
3203	41		41		figure 12.6 has low quality. It should be noted that there are low quality figures in the IPCC Chapters as usual.	**Accepted.** Figure 12.6 required more explicatory text - for which no space is available. Therefore, it has been deleted for the FGG.	Hamideh Dalaei	climatologist at Islamic Republic of IRAN Meteorological Organisation	Iran

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
31229	41		41		very complex and not really readable figure	**Accepted.** Figure 12.6 required more explicatory text - for which no space is available. Therefore, it has been deleted for the FGG.	Bruna Gaino	UCLouvain	Belgium
43441	41		41		figure 12.6 has low quality. It should be noted that there are low quality figures in the IPCC Chapters as usual.	**Accepted.** Figure 12.6 required more explicatory text - for which no space is available. Therefore, it has been deleted for the FGG.	sadegh zeyaeyan	Head of national center for forecasting and weather hazards management of Islamic Republic of Iran Meteorological Organization (IRIMO)	Iran
50347	41		41		figure 12.6 has low quality. It should be noted that there are low quality figures in the IPCC Chapters as usual.	**Accepted.** Figure 12.6 required more explicatory text - for which no space is available. Therefore, it has been deleted for the FGG.	Government of Iran	Islamic Republic of Iran Meteorological Organization (IRIMO)	Iran
57833	42	8	42	20	"… the number of refrigerators per capita in developing countries is one order of magnitude lower …" What is one order of magnitude lower? Be more specific (e.g., 50% lower than developed countries).	**Accepted**. Concrete numbers rom James and James (2010) added (19 versus 200 m3 refrigerated storage capacity per 1000 inhabitants).	Government of United State	U.S. Department of State	United States of America
10817	42	18	42	20	This is an excellent example of trade-off. All along this WG3 report the reader is often told how trade-offs, solutions to be avoided, are opposed to synergies. See also 12.6.2. Anyway situations will be found where one cannot escape trade-offs. This seems to be the case here.	**Noted.**	Philippe Waldteufel	CNRS	France
11875	42	21	42	30	"Transport" as a whole has a large contribution to GHG emissions if one consider all steps in the food system from transport of inputs (seeds, fertilizers etc) to the farm to the transport of food from shops by consumers. When lifecycle analyses show limited emissions from transport in the food system it is often because they report only one or two stages of transport, often only the stage to the retailer. Even for a bulk product like soy beans, transport and processing can cause much more emissions than the agriculture part, even more than land-use change (Escobar et al., 2020, Spatially-explicit footprints of agricultural commodities: Mapping carbon emissions embodied in Brazil's soy exports, Global Environmental Change Volume 62, May 2020, 102067). For vegetables transport and refrigeration is often a major source of emissions (A. Frankowska, H. K. Jeswani, and A. Azapagic "Environmental impacts of vegetables consumption in the UK" Science of the Total Environment 682 (2019) p. 80-105)	**Rejected**. The numbers provided include shipping of food commodities by air, rail, road, and over sea, as well as transport in agriculture and fisheries. These are global numbers; the text emphasizes also that there are supply chains where transport and/or storage are important sources of GHG emissions.	The Royal Swedish Academy	Kung. Skogs-och Lantbruksakademien	Sweden
57835	42	21	42	30	Why are emissions from road, aviation, and rail measured in megajoules, while all other emissions are measured in metric tons? Units should be same for comparison.	**Rejected**. This provideds a comparison of energy requirements of different transport modes. Though correlated, they can not be converted 1:1. We used the units provided in the original sources.	Government of United State	U.S. Department of State	United States of America
70591	42	21	42	30	this paragraph starts with G HG emissions and then goes on with energyconsumption. These metrics tend to minimise the contribution of air transport (as a whole and for food) to climate change by neglecting its non-G HG contribution (radiative forcing,see transport chapter)	**Accepted**. Reference to Chapter 10 has been included and the limitation that this referes to energy consumption only has been added.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
11877	42	31	42	32	The figure for emissions caused by production of fertilizers could be discussed. According to FAO 115 million ton N fertilizer is used and emissions from average N-fertilizer is in the range of 4-5 kg CO2e. The figure quoted is equal to emissions only in China (Chai, R., Ye, X., Ma, C. et al. Greenhouse gas emissions from synthetic nitrogen manufacture and fertilization for main upland crops in China. Carbon Balance Manage 14, 20 (2019). https://doi.org/10.1186/s13021-019-0133-9). In addition there is considerable methane leakage from the natural gas and fertilizer industries.	**Rejected**. The number refer to the production of ammonia only. EDGAR-FOOD uses the IPCC emissions factor of 1.69 kt CO2/t NH3 produced (IPCC 2016, Volume 3, Table 3.1).	The Royal Swedish Academy	Kung. Skogs-och Lantbruksakademien	Sweden
10819	42	36	42	40	This result is indeed reported by Poore and Nemecek. On the other hand, these authors stress that durable packaging can reduce food waste. They point out that distribution and retail losses may contribute 12 to 15% of emissions, while the sum of emissions from packaging, transport, and retail contributes just 1 to 9%. Here is another good case of trade-off!	**Noted**. The role of packaging for reducing food waste is assessed in Section 12.4.3.4.	Philippe Waldteufel	CNRS	France
57837	42	36	42	40	What are the options to reduce emissions from packaging arising from pulp and paper?	**Noted**. Mitigation options on packaging are discussed in Section 12.4.3.4. However, specific options on pulp and paper are too specific (but included in material reductions); mitigation in biomass production systems are discussed in other parts of the report.	Government of United State	U.S. Department of State	United States of America
43241	42	41	42	44	Waste. Management of waste generated in food system (including food waste, wastewater, packaging waste etc.) contributed 1.7 GtCO2-eq yr-1 42 to food systems' GHG emissions, 52% from domestic and 43 commercial wastewater, 40% from solid waste management, and 6.9% from industrial wastewater. 44 Emissions from waste incineration and other waste management systems contribute 1.1%. This should clarify if these are biogenic or fossil GHG emissions, since accounting of waste sector emissions frequently omit biogenic emissions.	**Accepted.** Clarified (biogenic)	Mariel Vilella	Zero Waste Europe/University of Manchester	United Kingdom (of Great Britain and Northern Ireland)
8159	43	1	43	7	Table 12.7: Please check what is reported here under "Land-use change and Forestry" and correct the table accordingly. The rows should read "forestry and other land-use" or "Land-Use, Land-Use Change and Forestry", but not "LUCF" - this would indicate that some emissions (the "land-use" part of LULUCF) are missing from the table.	**Accepted**. Table updated.	Joachim Rock	Thuenen-Institute of Forest Ecosystems	Germany
10027	43	1		3	Reference is made to the table 12.7 GHG emission from food systems ----- GHG emissions in 1990 and 2015. Suggestion. The unit measurement of the numbers (in %) is presented in head of the table (first row); the use of % on numbers reported under this table head are not necessary.	**Accepted**. Percent symbols deleted from table body.	Government of Indonesia	Ministry of Environment and Forestry	Indonesia

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
46219	43	1	43	7	Table 12.7: Please check what is reported here under "Land-use change and Forestry" and correct the table accordingly. The rows should read "forestry and other land-use" or "Land-Use, Land-Use Change and Forestry", but not "LUCF" - this would indicate that some emissions (the "land-use" part of LULUCF) are missing from the table.	**Accepted**. Table updated.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
57839	43	1	43	7	There is no reference to this table in the main body of the report.	**Accepted**. Reference to Table added.	Government of United State	U.S. Department of State	United States of
57841	43	1	43	7	Too much reliance is placed on one source for these data in Table 12.7. The emissions reported for "land-use change" are exaggerated and confusing. "Land use change" from what to what? Is this emissions from fire and land clearing? What if the land use is the same before and after the clearing process? Most fires globally occur in savannahs, repeatedly, sometimes 3x per year in one location, and land use is unchanged. The word "change" creates a misleading variable dependent upon selected points in time that are not defined. For example, the change from frequently burned grasslands to managed forests that has occurred under some community concessions in Central America is apparently not the change being estimated here.	**Noted.** To account for food system emissions, consistency ob the data used is crucial; Table 12.7 uses data from EDGAR which are used throughout this report. Terminology is according to the national greenhouse gas inventories, given by the IPCC guidelines. Burning of savannah is a separate source category and not lumped to LULUCF.	Government of United State	U.S. Department of State	United States of America
11879	43	9	46	20	The prominence given to results of lifecycle analysis when comparing emissions from various foods and diets is problematic on many counts. 1. Basically all lifecycle analyses are using the emission metric GWP-100 for methane. But as the report shows in Annex B, Appendix AB10 this metric has major limitations and works best in describing marginal changes and not ongoing emissions, which is largely the case in the food system (For further elaboration see John Lynch et al 2020 Environ. Res. Lett. 15 044023.). It basically constitutes a major bias against ruminants in general and against extensive pastoralism in particular. 2. The food and agriculture systems are dynamic and one can't extrapolate the value for individual products into full diets as allocation of emissions change when the system change. I.e. The calculation of emissions of vegetable oil is based on that oil cakes can be used as animal feed and therefore substantial emission is allocated to oils cakes. If consumption of vegetable oil would increase dramatically as proposed e.g. by Willet et al (2019) and consumption of animal products are dramatically reduced the emissions per kg of vegetable oil would approximately double. This is not captured by any of the studies referenced. 3. In a circular food system, animals play a very important role for using leftovers, natural grasslands etc. This is not captured by lifecycle analyses but is demonstrated e.g. by van Hal, O., de Boer, I. J. M., Muller, A., de Vries, S., Erb, K. H., Schader, C., Gerrits, W. J. J. & van Zanten, H. H. E., 10 May 2019, In : Journal of Cleaner Production. 219, p. 485-496 12 p. and Röös, Elin & Patel, Mikaela & Spångberg, Johanna & Carlsson, Georg & Rydhmer, Lotta, 2016. "Limiting livestock production to pasture and by-products in a search for sustainable diets," Food Policy, Elsevier, vol. 58(C), pages 1-13. 4. The diet scenarios are not tested against the realities of agriculture, soils and climate. What crops farmers can successfully depend on a multitude of factors and the proportion of different crops and animals in the production system is essential.	**Accepted**. **(1)** The data from Poore and Nemecek (2018) have been recalculated on the basis of AR6-GWP100; also the share of CH4 emissions from the main sources (manure management, enteric fermentation, and flooded rice) is indicated. The data are now displayed as figure rather than a table. **(2)** The Fibure caption has been extended to clarify the nature of the data: "*Ranges of GHG intensities [kgCO2-eq per 100 g of protein, 10th-90th percentile] in protein-rich foods, quantified via a meta-analysis of attributional Life Cycle Assessment studies using economic allocation (Poore and Nemecek, 2018; Parker et al., 2018)*". **(3)** A sentence on the results of the groups around Van Zanten and Roeoes has been included. "[...] *and ruminants fed on marginal land, crop residues, or food waste can provide human edible food with relatively low demands for cropland (Röös et al. 2016; van Zanten et al. 2018; Van Hal et al. 2019)*"	The Royal Swedish Academy	Kung. Skogs-och Lantbruksakademien	Sweden
22191	43	14	43	18	Adding land use change emissions shows that land use change emissions tend to be more important than production emissions, although the way yearly equivalent are computed may influence the results. Even though the value change importantly, the order is the same, beef is 188 kgCO2-eq (kg meat)-1, pork 20 188 kgCO2-eq (kg meat)-1, and poultry meat 14 kgCO2-eq (kg meat)-1 (Searchinger et al., 2018) https://www.nature.com/articles/s41586-018-0757-z	**Parly accepted.** Searchinger et al. (2019) propose a method taking carbon sequestration opportunity costs into account. The values presented here do not include this effect as it is currently not a standard methodology and reduced land use is a co-benefit that is assessed separately. However, a sentence was included indicating this potential " *Animal products also use more land than vegetable proteins, so switching consumption from animal to vegetable proteins could reduce agricultural land use, and this land could subsequently sequester substantial amounts of carbon if reforested, abandoned or set aside to regenerate (Searchinger et al. 2018; Schmidinger and Stehfest 2012; Hayek et al. 2021).* "	Government of France	Ministère de la Transition écologique et solidaire	France
70593	43	14	43	18	the figures do not seem the same as in table 12.8	**Editorial**	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
22189	43	17	43	18	Concerning the sources used here, there has been (unpublished) criticism to this publication for combining together all types of aquaculture products, and for using models for wastewater treatment (e.g. oxidation lagoons) to estimate CH4 emissions from fish ponds. The vast majority of farmed fish consists of Asian systems for herbivorous/omnivorous fish, featuring relatively lower impacts than other types of systems for carnivorous fish (salmon, etc) FAO (2020) The State of World Fisheries and Aquaculture 2020. Sustainability in action. Rome: Food and Agriculture Organization of the United Nations	**Noted**. No reference is given. However, we have added values for Norwegian seafood (Winther et al., 2020) that report 1.1 kg CO2-eq per kg for Herring up to > 8 kg CO2-eq per kg for salmon.	Government of France	Ministère de la Transition écologique et solidaire	France
22193	43	19	43	19	Concerning "multiple function" we suggest to add that in non-industrial livestock farming, cattle also contributes to soil fertily, lanscape maintenance and the conservation of biodiversity-rich pastures , in particular in mountain areas	**Accepted.** Sentence extended to include biodiversity preservation in semi-natural grasslands (Röös et al., 2016).	Government of France	Ministère de la Transition écologique et solidaire	France
22195	43	20	43	22	Concerning this sentence, does the livestock footprint also include the plant based food production that feeds livestock? We also suggest a rephrasing such as "Plant based foods have a significantly lower GHG footprint, both for production emissions (Poore and Nemecek 2018) and land use emissions (Searchinger et al. 2018)"	**Accepted**. Sentence modified accordingly.	Government of France	Ministère de la Transition écologique et solidaire	France

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
57843	43	20	43	22	Assumptions and text here need revision, clarification, and corrections. Current text states LUC emissions are high from soya, but for permanent crops like nuts and citrus are negative (e.g., net sequestration). These assertions are based on limited time frames and contexts. Citrus can cause more emissions than soy. Indeed, in Florida, wetlands were drained and filled for citrus, which later succumbed to disease, and the orchards and trees burned for disposal (LOTS of emissions from citrus in that scenario). Likewise, no-till soy on degraded lands could result in net sequestration over some years. It all depends on what prior land management regime is assumed and what time steps are analyzed. Emissions from clearing native vegetation and disturbing/tilling land are associated with every unit of agricultural land at some point in time and are not unique to "palm, soya oil, coffee" (contrary to what is stated). Both sequestration and emissions can be observed for nearly all crops, it just depends on when and where you look. Furthermore, this discussion omits the incredibly high productivity of African palm, and that it can serve as multi-story, multi-cropping system for up to 25 years prior to renewal. Finally, just because something is plant-based, does not make it better than meat. It always depends. https://www.frontiersin.org/articles/10.3389/fsufs.2019.00122/full https://www.jstor.org/stable/3987805	**Accepted.** The sentence has been modified to clarify that the data are based on the studies complied by Poore & Nemecek (2018) and emissions are context-specific (Meijaard et al. 2020 10.1038/s41477-020-00813-w)	Government of United State	U.S. Department of State	United States of America
81733	43		44		The section on GHG intensities of food items should consider the opportunity to show how different food item GHG intensities are also made up from different proportions of CO2, CH4 and N2O. The underlying Poore and Nemecek 2018 database usefully allows breakdowns by stage, and therefore in many cases by GHG. This type of useful analysis is exemplified by OurWorldInData: https://ourworldindata.org/carbon-footprint-food-methane; and suggest including this analysis as it would be more consistent with statements made in Section A.B.10 of Annex B (and literature cited within) regarding the ambiguity of single metric values for LCA data	**Accepted.** Data from Poore and Nemecek (2018) and Parker et al. (2018) have been recalculated on the basis of AR6-GWP100; additionally the share of methane from the main sources (manure management, enteric fermentation, and flooded rice) has been indicated.	Government of New Zealand	Ministry for the Environment	New Zealand
51831	44	4	44	7	The cited paper by Gerhardt et al. 2019 also includes cultured meat, so suggest to include this in the text here as well, as this opens up interesting additional mitigation and adaptation options compared to plant-based meat alternatives only.	**Accepted.** Sentence has been generalized and reads now 'At the same time, alternatives to animal-based meat and other livestock products …"	Florin Vladu	UNFCCC Secretariat	Germany
22197	44	10	44	10	Suggest to add a column on land use GHG emissions footprint from Searchinger et al. 2018, either using the table 1 in the article, or the more detailed table in the supplementary material informations for Table 12.8	**Rejected.** Carbon opportunity cost requires determination of a land use/C stock baseline, which is debated and assuming land owners would not use it for (other) income generation. This is beyond the scope and intention of this secction The approach of Searchinger has been mentioned in the text.	Government of France	Ministère de la Transition écologique et solidaire	France
51829	44	10	44	13	The table should also contain information on essential amino acid contents, which is a key component of the nutritional value of proteiins. Without consideration of amino acids proteins are basically not comparable. There is vast nutritional literature on this point, e.g. for a recent review article see: Hertzler, S.R.; Lieblein-Boff, J.C.; Weiler, M.; Allgeier, C. Plant Proteins: Assessing Their Nutritional Quality and Effects on Health and Physical Function. Nutrients 2020, 12, 3704. https://doi.org/10.3390/nu12123704	**Partially rejected**. Though interesting, this would go beyond the scope of this section; protein quality is touched upon in Section 12.4.3.3 where also the reference indicated has been added.	Florin Vladu	UNFCCC Secretariat	Germany
57845	44	10	44	13	There is no reference to this table in the main body of the report.	**Editorial**	Government of United State	U.S. Department of State	United States of
70595	44	10	44	12	Table 12.8 - aquaculture not included.	**Accepted.** The data are now presented as figure (rather than as a table) and include farmed fish and crustaceans.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
70597	44	10	44	17	Table 12.8, since complementary explanations are given for nuts, it would also be useful to explain that the differences in emissions between bovine meats and milk depend on the attribution ratios of GHGs between coproducts.	**Accepted.** We agree that giving complementary information would be needed for more food products, however, in view of space limitations we have removed the explanations for nuts from the text.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
82861	44	10	44	11	Include other protein rich foods that are also in Poore & Nemecek in this figure? Especially farmed crustaceans and cheese, which may be commonly considered as protein components of meals	**Accepted.** The data are now presented as figure (rather than as a table) and include farmed fish, crustaceans and cheese	Raychel Santo	Johns Hopkins Center for a Livable Future	United States of America
22199	44	19	44	20	this sentence would be more complete with an environmental dimension, making it: "Food systems are connected to other societal and environmental systems, such as the energy system, financial system, transport system, and biodiversity". The referenced study in this sentence (Leip et al.) misses information on the publication year (2020). The reference list at the end of the chapter needs to be updated: "Leip A, Bodirsky BL, Kugelberg S. The role of nitrogen in achieving sustainable food systems for healthy diets. 2020. Global Food Security 100408. https://doi.org/10.1016/j.gfs.2020.100408." also, a reference to the Kayal et al. 2019 article on this topic can be added to the sentence. REF: Kayal, M., Lewis, H., Ballard, J., Kayal, E. 2019. Humanity and the 21st century's resource gauntlet: a commentary on Ripple et al.'s article "World scientists' warning to humanity: a second notice". Rethinking Ecology 4: 21–30. https://doi.org/10.3897/rethinkingecology.4.32116	**Rejected.** Biodiversity can not be considered as a system as understood in the sentence and is therefore not comparable to the other systems mentioned. The indicated paper discusses principally equity aspects which are not the topic of this section.	Government of France	Ministère de la Transition écologique et solidaire	France
22201	44	20	44	20	It seems that the reference cited on this line misses the year	**Editorial**	Government of France	Ministère de la Transition écologique et solidaire	France
22203	44	21	44	23	to excplicite the link with sustainable development goals, we suggest completing the sentence as follows: "... (e.g., organic, conventional, etc.), with consequences on social and environmental footprints...".	**Accepted.** Sentence modified to include 'with environmental and social consequences'.	Government of France	Ministère de la Transition écologique et solidaire	France
57847	44	24	45	9	What is meant by the emissions from "outside the agriculture sector"? Provide an example.	**Accepted**. Clarified	Government of United State	U.S. Department of State	United States of

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
29561	45	1	45	3	Various frameworks have been proposed to assess the sustainability of food systems. Have any of these been applied? If so what are findings? We would appreciate if these questions are elaborated in the text.	**Accepted.** A sentence has been added "Data platforms are being developed, but so far comprehensive data for evidence-based food system policy is lacking (Fanzo et al., 2020). "	Government of Norway	Norwegian Environment Agency	Norway
57849	45	4	45	9	This paragraph, and Figure 12.8, need a much clearer explanation. It is not at all clear the text is consistent with the figure or the proxies measure what they are claimed to reflect.	**Accepted.** The section has been re-written to improve clarity.	Government of United State	U.S. Department of State	United States of America
57851	45	4	45	9	The x-axis of Figure 12.8 is referred to as "household expenditure on food." But, that is not the case. The figure illustrates the "wholesale cost for food," which is not necessarily the same thing as household expenditures.	**Accepted.** Text corrected	Government of United State	U.S. Department of State	United States of America
70599	45	4	45	9	almost impossible to read, please rephrase	**Accepted.** Paragraphs have been re-written	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
22205	45	7	45	7	It seems that the reference cited on this line misses the year	**Accepted.** Correced.	Government of France	Ministère de la Transition écologique et solidaire	France
57853	45	10	45	13	This paragraph addresses adequacy of diet without discussing climate change, adaptation, or mitigation. It should be reframed in that context.	**Rejected.** The section and plot address adequacy of diet within a food system approach and a GHG context, as two of the dimensions shows (GHG intensity and share of GHG emissions from energy use) are directly GHG relevant. The specific paragraph introduces the dimension for the health/nutrition related dimension. However, the section has been re-written to improve clarity.	Government of United State	U.S. Department of State	United States of America
81735	45	10	45	13	This analysis (including Figure 12.8) uses 'share of deaths' as an indicator for the health impact of food consumed in a respective region. It should be noted that fatalities are not a complete measure of health impacts from food (i.e. poor nutrition and likely poor quality of life but not the source of mortality), and that nutrition-focused approaches are also relevant.	**Accepted**. The sentence has been extended to clarify this limitation.	Government of New Zealand	Ministry for the Environment	New Zealand
57855	45	19	45	19	"food insecurity also affected" should be "food insecurity is also affected"	**Editorial**	Government of United State	U.S. Department of State	United States of
115	46	1	46	11	Fig. 12.8 is shrouding rather than elucidating the issues involved and should be simplified.	**Noted.** The section has been re-written to improve clarity. We hope that this helps in reading the figure which is already a simplified representation of food system outcomes in a GHG context.	Harry Aiking	Vrije Universiteit, Institute for Environmental Studies	Netherlands
8205	46	2	46	10	Figure 12.8: Please check and correct: Western Europe is missing, East Europe is given twice (with South and North).	**Editorial**	Joachim Rock	Thuenen-Institute of Forest Ecosystems	Germany
57857	46	5	46	5	Unclear why this figure is referring to GHG emissions from energy.	**Accepted.** The section has been re-written to improve clarity and to better explain the rationale behind the selection of the dimensions shown in the plot.	Government of United State	U.S. Department of State	United States of America
28785	46	12	57	31	Why isn't dietary shifts considered a food system mitigation opportunity in this section and in Table 12.9? It is mentioned earlier in the chapter as an opportunity for reducing emissions but not described here. If this particular section is supposed to focus on mitigation technologies specifically, that should be stated. I understand that an assessment of it is given in Chapter 7, but agricultural food production and fisheries mitigation opportunities are also described in more detail in Chapter 7, yet are still listed in Chapter 12 as a food system GHG mitigation opportunity. If production-based solutions are described to some extent in section 12.4.3, the consumption-based solutions should also be mentioned, even if Chapter 7 has a more in-depth look at them both.	**Accepted**. A paragraph on dietary shift - in particular the role of pulses - has been introduced in Section 12.4.3.1 and ''Dietary shift:" has also been introduced in Table 12.9.	Erin Biehl	Johns Hopkins Center for a Livable Future	United States of America
46221	46	12	47	30	To provide an understandable overview of the specific mitigation potentials of the different options, the integration of the figure from Clark et al (2020), https://doi.org/10.1126/science.aba7357, would be helpful.	**Accepted**. The findings of Clark at al (2020) have been included the introduction of the section.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
51833	46	12	46	16	This list includes elements that are very diffiucl to understand. Why would it make sense to address energy consumption in the food sector instead of at the stage of production, e.g. coal power plants? Why would it make sense to look at tractor fuel specifically, when what is required is a change in fuel emissions throughout all heavy machinery, including those for building, mining, forestry, etc. Where is the added value of looking at these kinds of emissions from the food systems perspective compared to the traditional sectors?	**Accepted.** Sentence has been clarified. Reducing energy consumption is addressed in the different sub-sections if 12.4.3. A shift in the energy mix is beyond the scope of this chapter and is discussed in Chapter 6.	Florin Vladu	UNFCCC Secretariat	Germany
29711	46	13	46	16	Please consider including"enhanced carbon sequestration" as an option to reduce GHG emissions from food systems here or at another appropriate place.	**Accepted.** Enhanced carbon sequestration has been included in the introductory sentence.	Government of Norway	Norwegian Environment Agency	Norway
81729	46	13	46	20	Suggest noting that substituting food items is not always appropriate for various reasons including those within a sustainability context (e.g. wider environmental and land-use impacts, nutrition, cost and accessibility, or cultural considerations).	**Accepted.** New sentences have been added to provide a more balanced assessment on supply and demand side options. Here, also the ' needs to overcome socio-cultural, knowledge, and economic barriers (see Section 12.4.5).' have been included.	Government of New Zealand	Ministry for the Environment	New Zealand
82867	46	17	46	18	Since pulses have been removed from this section and the accompanying table (compared to the last version of this report), it might be worth adding to this sentence an example of some of the foods that are included in "current technologies and food products." Given that pulses are healtheir and more sustainable than many of the alternatives described in this chapter (e.g., plant-based analogs, cellular ag), it would be worth calling out their importance even if they are not described in this section because they are not new technologies. See, for instance, Semba et al: https://www.sciencedirect.com/science/article/pii/S2211912421000304	**Accepted**. A paragraph on dietary shift - in particular the role of pulses - has been introduced in Section 12.4.3.1 and ''Dietary shift:" has also been introduced in Table 12.9.	Raychel Santo	Johns Hopkins Center for a Livable Future	United States of America
28783	46	20	47	3	The sentence beginning with "All food supply chain stages..." is confusing. Could break it up into two sentences to distinguish between food loss and food waste references.	**Accepted.** Sentence modified accordingly.	Erin Biehl	Johns Hopkins Center for a Livable Future	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
51835	46	20	46	20	Many of the 'new food products' should arguably also not have a place in a 'healthier diet'. Maybe this requires further differentiation between diets that are only low in GHGs, and diets that are lower in GHGs and actually healthier than what is currently consumed in many developed countries.	**Rejected**. None of the technologies is unhealthy per se, and can / need to be further develoed if products can have undesired health effects. The text includes aspects of nutritional quality and food safety concerns.	Florin Vladu	UNFCCC Secretariat	Germany
1447	46		46		figure 12.8 has low quality	**Editorial**	Hamideh Dalaei	climatologist at Islamic Republic of IRAN Meteorological Organisation	Iran
3205	46		46		figure 12.8 has low quality. It should be noted that there are low quality figures in the IPCC Chapters as usual.	**Editorial**	Hamideh Dalaei	climatologist at Islamic Republic of IRAN Meteorological Organisation	Iran
10029	46				The quality of 'Figure 12.8 Regional differences--- GHG emissions' can be improved.	**Editorial**	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
43443	46		46		figure 12.8 has low quality. It should be noted that there are low quality figures in the IPCC Chapters as usual.	**Editorial**	sadegh zeyaeyan	Head of national center for forecasting and weather hazards management of Islamic Republic of Iran Meteorological Organization (IRIMO)	Iran
50349	46		46		figure 12.8 has low quality. It should be noted that there are low quality figures in the IPCC Chapters as usual.	**Editorial**	Government of Iran	Islamic Republic of Iran Meteorological Organization (IRIMO)	Iran
11881	47	1	51	45	Table 12.9 The usage of D+ and D– seems to be the opposite of the explanation below the table? Controlled environment agriculture, especially indoor farming with LED lights, has very high emissions per kcal produced. (Graamans et al. 2018, Plant factories versus greenhouses: Comparison of resource use efficiency, Agricultural Systems 160 (2018) 31-43.) It is only used for luxury greens with no relevance for nutrition or food supply. The claims of land and water saving are not including land and water use for energy production. In addition the water used for hydroponics or aquaponics is mostly of municipal drinking water quality and can't be compared with rain water or even agriculture irrigation water.It can hardly be called "transformative" and the technology is known since 100 years (although considerably improved).	**Accepted**. The 'direct emissions' refer to GHG emissions excluding energy demand, which is indicated by a separate flag (E- and E+) indeed, controlled environment agriculture is marked with E-. The explanation below the table has been clarified.The reference indicated has been included in the Table.	The Royal Swedish Academy	Kung. Skogs-och Lantbruksakademien	Sweden
43243	47	3	47	5	Chapter 8 does not address the GHG emissions mitigation potential in the waste management sector. Since this sector is cross-sectoral, may be included as a special section in Chapter 12. Here's a proposal for an alternate text written by Neil Tangri tangri@stanford.edu Alternate Text: IPCC AR6 WG3 8.3.4.2 Urban Waste Management The waste sector is a significant source of greenhouse gas emissions, particularly methane, which is receiving increased scrutiny due to its growing atmospheric levels and high short-term impact (Kaza et al., 2018; Nisbet et al., 2019). As waste management systems are usually under the control of municipal authorities, they are a ripe target for city-level mitigation efforts (Kaza et al., 2018). Three overlapping and congruent conceptual frameworks govern waste management: the Waste Hierarchy, the Circular Economy, and Zero Waste. The Waste Hierarchy ranks five main system interventions according to their beneficial environmental impacts, including climate mitigation: waste reduction/avoidance is the top priority, followed by reuse, recycling, energy recovery and, finally, waste disposal (European Commission, 2015; Gharfalkar et al., 2015). The Circular Economy has been defined as "a regenerative system in which resource input and waste, emissions, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling" (Geissdoerfer et al., 2017). Zero Waste is defined as "The conservation of all resources by means of responsible production, consumption, reuse, and recovery of products, packaging, and materials without burning and with no discharges to land, water, or air that threaten the environment or human health." (Simon, 2019; Zero Waste International Alliance, 2018). Zero Waste also puts greater emphasis on co-benefits, including environmental justice, increased employment, reduced toxic pollution, and lower costs (Connett, 2013; EJOLT, n.d.; Herrero & Vilella, 2018). These frameworks have evolved as a corrective to municipal waste practices which too often emphasize disposal at the cost of environmentally and financially preferable strategies (Zaman & Ahsan, 2019). There are three principal avenues through which waste management can contribute to GHG emissions	**Accepted.** Reference to Chapter 8 has been deleted. The proposed text has been forwarded to Chapter 8.	Mariel Vilella	Zero Waste Europe/University of Manchester	United Kingdom (of Great Britain and Northern Ireland)
46223	47	7	47	7	We suggest to separate 'fisheries' in a sense of wild stock fisheries fully from agriculture and aquaculture. Wild stock fisheries relies on harvest from a common property, while both harvest from agriculture and aquaculture depend on individual or corporate ownerships. Both food production in agriculture and aquaculture depend on human activities that coincide with the emission of greenhouse gases. In wild stock fisheries, growth of the goods of interest per se is independent of human activity coinciding with the emission of greenhouse gases. Only the harvest and storage of wild stock fisheries goods is associated with GHG production. In other words, protein harvested from agriculture and aquaculture coincides with higher GHG emission compared with wild stock fisheries. The latter, in combination with ocean fertilization might even serve as carbon sink (table 12.6).	**Accepted.** Wording has been changed to "Food production from agriculture, aquaculture and fisheries "	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
22207	47	12	47	28	This paragraph is very technology and industry based, while there is increasing evidence that a return to traditional farming may be a most livable global solution. we suggest adding this sentence at the end of the paragraph to emphasize this alternative path: "Alternatively, there is increasing evidence that a return to local, small-scale farming based on agroecological practices is necessary to sustainably mitigate GHG emissions, preserve biodiversity, promote social well-being, and be resilient to climate change (Altieri & Nicholls 2017; FAO 2017; Kayal et al. 2019)". REFs: - Altieri MA, Nicholls CI. 2017. The adaptation and mitigation potential of traditional agriculture in a changing climate. Climatic Change, 140: 33–45. - FAO (2017) The Future of Food and Agriculture – Trends and Challenges. Rome. www.fao. org/3/a-i6583e.pdf - Kayal, M., Lewis, H., Ballard, J. and E. Kayal. 2019. Humanity and the 21st century's resource gauntlet: a commentary on Ripple et al.'s article "World scientists' warning to humanity: a second notice". Rethinking Ecology 4: 21–30. https://doi.org/10.3897/rethinkingecology.4.32116	**Accepted**. A sentence on agro-ecology has been added to this paragraph,	Government of France	Ministère de la Transition écologique et solidaire	France
22209	47	24	47	25	We suggest to rephrase this sentence, for example "The effectivness of mitigation strategies relying on energy to substitute land is thus inherently linked with increasing energy efficiency and the use of energy from renewable sources."	**Accepted**. Sentence has been updated accordingly.	Government of France	Ministère de la Transition écologique et solidaire	France
61857	47	24	47	25	"The effectiveness in climate mitigation is thus inherently linked with increasing energy efficiency and the use of energy from renewable sources." This statement seems biased and is not technology neutral: how would renewables be superior to other low-carbon energy sources in this sense? Please rephrase "energy from renewable sources" to "energy from low-carbon sources".	**Accepted**. Sentence has been updated accordingly.	Rauli Partanen	Think Atom	Finland
65897	47	24	47	25	"The effectiveness in climate mitigation is thus inherently linked with increasing energy efficiency and the use of energy from renewable sources." Renewables are not superior to other low-carbon energy sources. Rephrase "energy from renewable sources" to "energy from low-carbon sources".	**Accepted**. Sentence has been updated accordingly.	Eero Hirvijoki	Aalto University	Finland
5543	47	25	47	25	replace Renewables" by "low carbon sources"	**Accepted**. Sentence has been updated accordingly.	Michel SIMON	Retraité/ Pdt d'association	France
27851	47	25	47	25	Delete "and the use of energy from renewable sources", as the cost of RE is still higher in some regions.	**Partly rejected.** The sentence has been changed from using 'low-carbon energy sources' instead of 'renewable energy sources'.	Eleni Kaditi	Organization of the Petroleum Exporting Countries, OPEC	Austria
22211	47	27	47	27	Concerning "BSE", Bovine spongiform encephalopathy? please define abbreviations at first use	**Noted.** We have maintained only the example of COVID-19.	Government of France	Ministère de la Transition écologique et solidaire	France
57859	47	29	47	30	Table 12.9 title should appear on the next page with the table.	**Editorial**	Government of United State	U.S. Department of State	United States of
11883	48	1	52	4	Interesting Food system mitigation opportunities.	**Noted.**	The Royal Swedish Academy	Kung. Skogs-och Lantbruksakademien	Sweden
46225	48	1	48	1	We suggest to separate wild stock fisheries from agriculture, please see also comment on 12-47-7.	**Accepted.** Wording has been changed to "Food production from agriculture, aquaculture and fisheries "	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
57861	48	1	55	1	Table 12.9 cites Folberth et al. (2020) but the text omits the key points and conclusions from that and other papers. This discussion might best fit in the section on Land, starting page 68. Correct the omission by adding something like the following to help readers understand: ""Estimates vary depending on assumed technologies and diets, but between 50% (Folberth et al., 2020) and 80% (Kline et al., 2017) of current croplands could be managed for other purposes or returned to native vegetation while feeding the world for the next 20 years on remaining land, if only the best lands and practices were used to efficiently grow food via integrated cropping and nutrient cycling systems. Optimizing where and how crops are grown, and reducing the footprint of agriculture, can be done at low cost and provides enormous and swift benefits to biodiversity conservation as well as GHG emissions (Beyer et al., 2019)."" References: Robert M. Beyer, Andrea Manica, Tim T. Rademacher, 2019, Relocating agriculture could drastically reduce humanity's ecological footprint. https://www.biorxiv.org/content/10.1101/488841v4.full doi: https://doi.org/10.1101/488841 Kline KL, Msangi S, Dale VH, Woods J, Souza G, Osseweijer P, Clancy J, Hilbert J, Mugera H, McDonnell P, Johnson F. 2017. Reconciling food security and bioenergy: priorities for action. Global Change Biology Bioenergy 9(3):557-576. http://onlinelibrary.wiley.com/doi/10.1111/gcbb.12366/full Folberth et al. (already in reference list, but see also: https://www.sciencedaily.com/releases/2020/04/200416114539.htm)	**Accepted.** While the table doesn't offer sufficient space to go in-depth, we have added this aspect by generalizing the option to 'Sustainable intensification and land use optimization'. The reference of Beyer et al. 2018 has not been peer reviewed and cannot be included.	Government of United State	U.S. Department of State	United States of America
70601	48	1	52	4	the table is so long that it would ease reading if the explanations at the end page 52 were somehow moved to the beginning of the table	**Accepted.** Table has been re-designed and condensed; explanatory text is given above the table.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
22213	49		49		Table 12.9, 4th column, 2nd row, we recommand t add : "E- (higher emissions through entire dependence on inorganic fertilizers that induce GHG emissions during production and transport)."	**Rejected.** There is no evidence that GHG emissions through production and transport of fertilizers outweigh reductions in energy use as a consequence of more efficient production methods. We have added 'E0 (mixed effects)'	Government of France	Ministère de la Transition écologique et solidaire	France

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22215	49		49		Table 12.9, 3rd row : Perhaps integrated multi-trophic aquaculture (IMTA) systems should be mentioned here and in 12.4.3.3. E.g.: Erickson C (2020) A Review of the Methods and Metrics in Research, Implementation, and Management of Integrated Multi-Trophic Aquaculture. Master's Proj Capstones 1028 Sanz-Lazaro C, Sanchez-Jerez P (2020) Regional Integrated Multi-Trophic Aquaculture (RIMTA): Spatially separated, ecologically linked. J Environ Manage 271:110921. https://doi.org/10.1016/j.jenvman.2020.110921 Knowler D, Chopin T, Martínez-Espiñeira R, et al (2020) The economics of Integrated Multi-Trophic Aquaculture: where are we now and where do we need to go? Rev Aquac 12:1579–1594. https://doi.org/10.1111/raq.12399 Gamito S, Quental-Ferreira H, Parejo A, et al (2020) Integrated multi-trophic aquaculture systems: energy transfers and food web organization in coastal earthen ponds. Aquac Environ Interact 12:457–470. https://doi.org/10.3354/aei00375	**Accepted.** 'integrated aquaculture approaches (Sanz-Lazaro and Sanchez-Jerez 2020; Knowler et al. 2020)' have been included in the introductory paragraph of Section 12.4.3.1	Government of France	Ministère de la Transition écologique et solidaire	France
18499	50	1	50	1	Table 12.9 -Cellular Agriculture is given the co-benefit of "increased food safety for consumption of animal food, potentially reduced risk from zoonotic diseases, pesticides and antibiotics". Could the authors please revise the sentence to reflect the number of concerns/challenges to food safety and product authorisation linked to the use of required growth promoters etc., with only one example authorised for consumer consumption at present. This same comment applies to Table TS.4. I would recommend removing the text "increased food safety for consumption of animal food"	**Accepted.** In order to provide a differentiated assessment we have extended the sentence (rather then deleted) as follows 'H0 Increased food safety for consumption of animal food, potentially reduced risk from zoonotic diseases, pesticides and antibiotics; safety concerns for the use of growth promoters)'. We have also re-assessed the health effect to H0. This is discussed in Chriki and Hocquette (2020) which was already in the references cited.	Government of United Kingd	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
46227	50	1	50	1	Regarding the mitigation option "Plant-based protein sources (analogues)" plant based milk alternatives should be explicitly mentioned, too, since milk consumption is a major source for GHG emissions and driver behind beef meat supply.	**Accepted.** Re-formulated "Plant-based protein sources (meat, milk and egg analogues)"	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
12057	51	25	52	2	Basing the statement 'Taken together, these studies raise serious concerns about the distribution of SRM impacts across countries and vulnerable groups' is overstating the case and evidence. The statement is based on only two papers, by the same author. The statement should be balanced by a statement that SAI, if successful could help avoid the substantial health effects of the avoided warming. In addition, at least one study of SAI has quantified air quality benefits of stratospheric ozone depletion, finding that marginal decreases in stratospheric ozone values could result in a net reduction in global mortality due to competing health impact pathways, highlighting the need for research to better understand the full health and environmental trade-offs involved in any future policy decisions regarding SAI (Eastham et al., 2018). Further, other studies have recommended that a comprehensive risk assessment effort to understand the health effects of SRM is needed (Effiong and Neitzel, 2016). Both the papers referenced (Carlson) are missing in the references. EASTHAM, S., KEITH, D. & BARRETT, S. 2018. Mortality trade off between air quality and skin cancer from changes in stratospheric ozone. Environmental Research Letters, 13. EFFIONG, U. & NEITZEL, R. L. 2016. Assessing the direct occupational and public health impacts of solar radiation management with stratospheric aerosols. Environmental health : a global access science source, 15, 7-7. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4717532/	Rejected. SRM is outside the scope of chapter 12. SRM is considered as a cross-working groups issue, the governance part of it is dealt with in chapter 14.	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
12055	52	20	52	31	Suggest adding that studies suggest there is no likely scenario in which rapid cessation of SAI might be expected – for example PARKER, A. I., PETER J. 2018. The Risk of Termination Shock From Solar Geoengineering. Earth's Future, 6, 456-467.	Rejected. SRM is outside the scope of chapter 12. SRM is considered as a cross-working groups issue, the governance part of it is dealt with in chapter 14.	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
22217	53	1	53	1	Despite this title, fisheries innovation, especially coastal ones, are not mentionned in this part.	**Accepted.** A sentence on intergrated multi-tropic aquaculture has been added, as well as a remark on the limited literature on aquaculture and fisheries in the context of GHG mitigation has been added.	Government of France	Ministère de la Transition écologique et solidaire	France
46229	53	1	53	4	We suggest to separate wild stock fisheries from agriculture, please see also comment on 12-47-7.	**Accepted.** The title has been changed to '12.4.3.1 Food production from agriculture, aquaculture and fisheries '. A sentence on intergrated multi-tropic aquaculture has been added, as well as a remark on the limited literature on aquaculture and fisheries in the context of GHG mitigation has been added.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
75535	53	1	53	16	There should be more descriptions of fisheries and aquaculture. GHG emissions per unit of production vary greatly depending on the fishing/aquaculture methods, the type of seafood (shellfish, seaweed, fish), whether it is freshwater or marine fishery/aquaculture, and whether it is fed. See Aubin et al. (2009); Papatryphon et al. (2003);Grönroos et al. (2006); Pelletier & Tyedmers (2010);Winther et al. (2009)/Ziegler et al. (2013), etc. It should be added that the number of papers on GHG emissions from fisheries/acuaculture is limited and further study is needed.	**Accepted.** Additional information on fisheries and aquaculture has been added to section 12.4.2.2. (based on Winther et al., 2020) and in Section 12.4.3.1 (in multi-trophical aquaculture, (Sanz-Lazaro and Sanchez-Jerez 2020; Knowler et al. 2020).A remark on the limited literature on aquaculture and fisheries in the context of GHG mitigation has been added.	Mai FUJII	Sasakawa Peace Foundation, Ocean Policy Research Institute	Japan

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
80707	53	2	53	10	In addition to support to encourage subsistence and small-scale farmers to transition towards sustainable agriculture and circular economy (Blandforth & Hassapoyannes, 2018), fast-acting and cost-effective measures to control N2O and CH4 emissions from conventional farming techniques should be adopted. For instance, two manure additives by SOP—SOP LAGOON and Star COW—have shown potential to reduce CH4 and N2O emissions (Peterson et. al., 2019; Ross, 2020). Nitrogen inhibitors have the potential to reduce agricultural N2O emissions by 12 MtCO2e (GWP100) (U.S. E.P.A. (2019)). Further, the Common Agriculture Program (CAP) is undergoing reform that shows potential and may serve as an example for agricultural policies targeting CH4 and N2O emissions. The CAP provides direct payments to farmers that comply with the statutory management requirements (e,g, Nitrates Directive) and land maintenance requirements. Reforms will include a new feature called Eco-Schemes that will require countries to allot a certain portion of their CAP budgets towards farmers that implement environmental and climate measures. If measures to be adopted are ambitiously designed and aligned with the modern EU policies, the CAP Program can contribute reduction up to 101 million tonnes of CO2e—about 23.8% of the EU's agriculture and agricultural land use emissions. The Eco-Schemes program, alone, can moblize 72 million tonnes of CO2e (Scheffler & Wiegman, 2020). CITATIONS: Blandforth, D. and Hassapoyannes, K. The role of agriculture in global GHG mitigation, OECD Food, Agriculture, and Fisheries Papers No. 112 at 36 ("Another challenge associated with technical mitigation options in agriculture relates to risks to food security. This is because the technical mitigation options, focusing on reducing emissions per unit of land or animal, most of the time do not have a significant positive effect on output. In some cases they may even reduce output level (e.g. reduced tillage or rewetting of organic soils) in the absence of compensating changes in productivity. Thus, the required increases in output to meet the anticipated future growth in demand may not be achievable with technical mitigation options under current land use.). Peterson, C., et. al. (2020). Effects of SOP Lagoon Additive on Gaseous Emissions from Stored Liquid Dairy Manure, Sustainability 12: 1–17, 12 ("Compared to the CONT, the HIGH treatment achieved average emission reductions of 22.7% and 14.7% for CH4 and CO2, respectively ($p < 0.05$). The HIGH vs CONT treatment also showed an emission reduction of 45.4% for N2O."). Ross E. G., et. al. (2020) Effect of SOP "STAR COW" on Enteric Gaseous Emissions and Dairy Cattle Performance, Sustainability 12(24): 1–12, 1 ("The aim of	**Rejected.** Reference to Chapter 7 is given where details on agricultural mitigation opportunities are discussed.	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America
80851	53	2	53	10	In addition to support to encourage subsistence and small-scale farmers to transition towards sustainable agriculture and circular economy (Blandforth & Hassapoyannes, 2018), fast-acting and cost-effective measures to control N2O and CH4 emissions from conventional farming techniques should be adopted. For instance, two manure additives by SOP—SOP LAGOON and Star COW—have shown potential to reduce CH4 and N2O emissions (Peterson et. al., 2019; Ross, 2020). Nitrogen inhibitors have the potential to reduce agricultural N2O emissions by 12 MtCO2e (GWP100) (U.S. E.P.A. (2019)). Further, the Common Agriculture Program (CAP) is undergoing reform that shows potential and may serve as an example for agricultural policies targeting CH4 and N2O emissions. The CAP provides direct payments to farmers that comply with the statutory management requirements (e,g, Nitrates Directive) and land maintenance requirements. Reforms will include a new feature called Eco-Schemes that will require countries to allot a certain portion of their CAP budgets towards farmers that implement environmental and climate measures. If measures to be adopted are ambitiously designed and aligned with the modern EU policies, the CAP Program can contribute reduction up to 101 million tonnes of CO2e—about 23.8% of the EU's agriculture and agricultural land use emissions. The Eco-Schemes program, alone, can moblize 72 million tonnes of CO2e (Scheffler & Wiegman, 2020). CITATIONS: Blandforth, D. and Hassapoyannes, K. The role of agriculture in global GHG mitigation, OECD Food, Agriculture, and Fisheries Papers No. 112 at 36 ("Another challenge associated with technical mitigation options in agriculture relates to risks to food security. This is because the technical mitigation options, focusing on reducing emissions per unit of land or animal, most of the time do not have a significant positive effect on output. In some cases they may even reduce output level (e.g. reduced tillage or rewetting of organic soils) in the absence of compensating changes in productivity. Thus, the required increases in output to meet the anticipated future growth in demand may not be achievable with technical mitigation options under current land use.). Peterson, C., et. al. (2020). Effects of SOP Lagoon Additive on Gaseous Emissions from Stored Liquid Dairy Manure, Sustainability 12: 1–17, 12 ("Compared to the CONT, the HIGH treatment achieved average emission reductions of 22.7% and 14.7% for CH4 and CO2, respectively ($p < 0.05$). The HIGH vs CONT treatment also showed an emission reduction of 45.4% for N2O."). Ross E. G., et. al. (2020) Effect of SOP "STAR COW" on Enteric Gaseous Emissions and Dairy Cattle Performance, Sustainability 12(24): 1–12, 1 ("The aim of	**Rejected.** Reference to Chapter 7 is given where details on agricultural mitigation opportunities are discussed.	Gabrielle Dreyfus	Institute for Governance & Sustainable Development	United States of America
46231	53	4	53	4	We suggest to treat fisheries and aquaculture separately, since they have a different biological basis, different management mechanisms and also a different legal basis. FAO (1988) introduced a definition of aquaculture which reduces its confusion with capture fisheries: Aquaculture is the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated. For statistical purposes, aquatic organisms which are harvested by an individual or corporate body which has owned them throughout their rearing period contribute to aquaculture, while aquatic organisms which are exploitable by the public as a common property resources, with or without appropriate licences, are the harvest of fisheries. Please see also comment on 12-47-7.	**Accepted.** The title has been changed to '12.4.3.1 Food production from agriculture, aquaculture and fisheries '. A sentence on intergrated multi-tropic aquaculture has been added, as well as a remark on the limited literature on aquaculture and fisheries in the context of GHG mitigation has been added.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
11885	53	17	54	12	Controlled environment agriculture, especially indoor farming with LED lights, has very high emissions per kcal produced. (Graamans et al. 2018, Plant factories versus greenhouses: Comparison of resource use efficiency, Agricultural Systems 160 (2018) 31-43.) It is only used for luxury greens with no relevance for nutrition or food supply. The claims of land and water saving are not including land and water use for energy production. In addition the water used for hydroponics or aquaponics is mostly of municipal drinking water quality and can't be compared with rain water or even agriculture irrigation water.It can hardly be called "transformative" and the technology is known since 100 years (although considerably improved).	**Rejected.** As indicated in the section the main energy requirement is from cooling, so - while correct - the energy requirement from LED is in most cases secondary. Mitigation options through improved lightning is mentioned though. The reference has been added to Table 12.9 . Agricultural production uses also blue water, and some CEAs use grey or black water. Most technologies are not 'new' (e.g. fermemtation is very old) but are assessed here because of their potential to be scaled up.	The Royal Swedish Academy	Kung. Skogs-och Lantbruksakademien	Sweden
46233	53	20	53	20	"…flow-through re-circulating aquaculture…" is contradictory; delete "flow through"	**Editorial**	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
57863	53	27	53	27	"take often" should be "often take"	**Editorial**	Government of United State	U.S. Department of State	United States of
57865	53	28	53	28	Can zoning be an impediment to such repurposing of urban infrastructure?	**Noted.** Comment unclear - no change needed.	Government of United State	U.S. Department of State	United States of
57867	53	31	53	31	"possibly can further enhanced" should be "possibly can be further enhanced"	**Editorial**	Government of United State	U.S. Department of State	United States of
22219	53	40	53	40	Concerning LEDs, although using LEDs may be questionable if energy and GHG emissions costs are taken into account in the global C budget (production, transport, utilization and recycling).	**Noted**. The high energy requirement of CEAs is emphasized in the text.	Government of France	Ministère de la Transition écologique et solidaire	France
28787	53	47	54	2	The sentence reads as if controlled environment food production can meet all consumer demands, which is unlikely - suggest rewording it to say that it can meet some consumer demand for locally produced fresh and diverse produce throughout the year	**Accetped**. Sentence modified accordingly	Erin Biehl	Johns Hopkins Center for a Livable Future	United States of America
61859	54	5	54	8	"Options for increasing performance and thus reducing GHG intensity of food products include reducing energy need through improved lighting and cooling efficiency, and by employing renewable energy sources, partly integrated into the building structure (Benke and Tomkins 2017)." It would seem that any low-carbon energy source would work, whether integrated into the building structure or not. Further, a source of energy that can be provided on-demand, such as nuclear energy, would likely work even better than a variable source of energy. Please rephrase "employing renewable energy" to "employing low-carbon energy" to be scientifically more accurate and technologically neutral.	**Accepted**. Changed to low-carbon energy sources.	Rauli Partanen	Think Atom	Finland
65899	54	5	54	8	"Options for increasing performance and thus reducing GHG intensity of food products include reducing energy need through improved lighting and cooling efficiency, and by employing renewable energy sources, partly integrated into the building structure (Benke and Tomkins 2017)." Did Benke and Tomkins provide a justification why only renewables would be able to provide low-carbon energy? Rephrase "employing renewable energy" to "employing low-carbon energy".	**Accepted**. Changed to low-carbon energy sources.	Eero Hirvijoki	Aalto University	Finland
5545	54	7	54	7	replace Renewables" by "low carbon sources"	**Accepted**. Changed to low-carbon energy sources.	Michel SIMON	Retraité/ Pdt d'association	France
82871	54	32	54	46	One study modeled potential dietary shifts in 140 countries away from current consumption patterns to a "low food chain" diet that was predominantly plant-based but included protein from insects, bivalve mollusks, and forage fish. Specifically, protein from insects replaced 10% of the protein from terrestrial animal products, and protein from forage fish and bivalve mollusks replaced 70% and 30%, respectively, of the protein from aquatic animals. The per capita reductions in cradle-to-farm gate GHG emissions associated with the "low food chain" diet were comparable to those of a vegan diet (on average, low food chain diets led to a 68% reduction - or a savings of 976 kg CO2e/capita/year - compared to baseline diets; vegan diets led to a 70% reduction). These low food chain diets also met the recommended intake of vitamin B12 for adults in 49% of study countries, illustrating that there may be ways to mitigate this potential limitation of plant-forward diets even without supplementation, at least for the general population. See Kim et al (https://www.sciencedirect.com/science/article/pii/S0959378018306101)	**Accepted.** The information has been used to improve the paragraph on algae and bivalves; results from Kim et al. (2020) were already included in Section 12.4.2.2.	Raychel Santo	Johns Hopkins Center for a Livable Future	United States of America
22221	54	45	54	46	Linking their potential to filter pollutants and their food function is debatable. Though they can do both, it is uncertain that bivalves used to filter pollutants can be consumed thereafter.	**Partially rejected.** The sentence clearly indicated that 'care is to be taken to avoid accumulation of hazardous substances '. However, to avoid misunderstandings the words 'nutrient-polluted' waters have been deleted.	Government of France	Ministère de la Transition écologique et solidaire	France
70603	55	10	55	10	first giving the figure of CO2 equivalent by grams of product whereas in the following paragraphs figures are given by grams of protein is a bit confusing	**Noted.** Both units are given to improve comparability to other numbers provided (e.g. in Section 12.4.2.2)	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
82863	55	11	55	13	The mean footprint of meat analogs as reported by Santo et al (2020) was actually 2.2 kg CO2e/100 g protein (see tab 5 "avg by product type" in the supplementary data). This averages the footprints based on a weighted average by study to avoid over-representing the results of studies that included more products from the same company than those that included fewer.	**Accepted.** Corrected	Raychel Santo	Johns Hopkins Center for a Livable Future	United States of America
57869	55	15	55	15	Unclear what is meant by this sentence.	**Accepted.** Clarified (conservation --> preservation).	Government of United State	U.S. Department of State	United States of
57871	55	16	55	16	Remove "of" in "processes that use of micro-organisms"	**Editorial**	Government of United State	U.S. Department of State	United States of
57873	55	19	55	20	Remove "as" in "other food as cell tissues"	**Editorial**	Government of United State	U.S. Department of State	United States of
57875	55	25	55	26	Repetitive text regarding muscle cells to produce cell tissues/cultured meat.	**Editorial**	Government of United State	U.S. Department of State	United States of
22223	55	35	55	35	Suggestion to replace "GHG intensities" with "production emissions GHG intensities" explanation: those emissions do not include land use change related emissions	**Rejected.** The data provided by Parodi et al. (2018) are based on LCA studies and include land use change emissions for animal-source and plant-source foods.	Government of France	Ministère de la Transition écologique et solidaire	France

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
61861	55	38	55	40	"As the main source of GHG emissions from insects and cellular agriculture foods is the use of energy, these foods can profit from increased use of renewable energy". It seems “renewable” should be rephrased into “low-carbon” energy to be scientifically more accurate and technology neutral, as by definition, GHG emissions can be brought down by using low-carbon energy (of which not all is renewable, and as not all renewable energy is low-carbon nor sustainable).	**Accepted**. Changed to low-carbon energy sources.	Rauli Partanen	Think Atom	Finland
65901	55	38	55	40	"As the main source of GHG emissions from insects and cellular agriculture foods is the use of energy, these foods can profit from increased use of renewable energy". I believe they would benefit from any low-carbon energy source? Rephrase "use of renewable energy" with "use of low-carbon energy".	**Accepted**. Changed to low-carbon energy sources.	Eero Hirvijoki	Aalto University	Finland
5547	55	40	55	40	replace Renewables" by "low carbon sources"	**Accepted**. Changed to low-carbon energy sources.	Michel SIMON	Retraité/ Pdt d'association	France
74249	55	40	55	40	Revise this sentence to strike "renewable" and insert "carbon free" to reflect the role that clean non-reneable generation including nuclear and hydro among others will play in meeting the future demand for fossil free food production.	**Accepted**. Changed to low-carbon energy sources.	Jeffrey Merrifield	Pillsbury Law Firm	United States of America
83671	55	42	55	46	Production of future foods such as plant-based analogues of meat cannot provide the ecosystem servises that sustainably raised livestock such as grassfed livestock can provide. Further, currently, most plant-based alternatives of meat tend to be extensively(or ultra-)-processed and hence in their current form, they can contribute to the global syndemic of obesity. Therefore, it is important to highlight here that the shift towards plant-based diets should primarily occur through promotion and utilisation of diverse plant foods that are at present underutilised, e.g. millets, negelected vegetables, etc.	**Accepted.** A sentence has been added to the introduction in Section 12.4.3. that "a shift to a diet with lower GHG intensity and rich in plant-based foods, particularly by increasing the share of pulses, nuts, fruits & vegetables for most can be healthy (Springmann et al, 2018, Willett et al., 2019; Bodirsky et al. 2020; Semba et al., 2020; Theurl et al. 2020; Coste Leite et al., 2020; Chen et al. 2019; Jarmul et al. 2020; Hamilton et al., 2021), [...]". A sentence has also been added to the indicated paragraph assessing the role of plant-based meats "[...] although more research is needed including allergenic effects and possibly reduced protein bioavailability (Alexander et al. 2017; Stephens et al. 2018; Parodi et al. 2018; Santo et al. 2020; Fasolin et al. 2019; Chriki and Hocquette 2020) (medium evidence, high agreement) or high or ultra-processing of some products (Wickramasinghe et al. 2021), though a randomized crossover trial comparing appetizing plantfood versus meat alternative found several beneficial but not adverse effects from the consumption of the plant-based meats (Crimarco et al. 2020)".	Lakshmi Dave	Massey University	New Zealand
22225	56	6	56	6	We recommand to either add a reference to this statement or to remove it	**Accepted.** The sentence is correct but the word 'optimise' can be misunderstood, as the debate around UFP shows. Indeed, UFP optimis nutritional qualities towards high palatability. The sentence has been deleted.	Government of France	Ministère de la Transition écologique et solidaire	France
22227	56	17	56	17	Concerning the "optimisation of food procesing facilities", it particularly relevant in developing countries lacking cold chain for the preservation and distribution of fresh perishable products such as fresh fish. In some countries where there is a long tradition of fish drying and smoking it requires technical improvements for lowering environmental and health impacts. E.g.: Adeyeye SAO, Oyewole OB (2016) An Overview of Traditional Fish Smoking In Africa. J Culin Sci Technol 14:198–215. https://doi.org/10.1080/15428052.2015.1102785 Adeyeye SAO (2017) The role of food processing and appropriate storage technologies in ensuring food security and food availability in Africa. Nutr Food Sci 47:122–139. https://doi.org/10.1108/NFS-03-2016-0037	**Accepted.** A sentence has been added 'The role of food processing preservation is particularly relevant in developing countries lacking cold chains for the preservation and distribution of fresh perishable products as as fresh fish (Adeyeye 2017; Adeyeye and Oyewole 2016)'.	Government of France	Ministère de la Transition écologique et solidaire	France
43245	56	22	56	27	The discussion about packaging needs further elaboration. Packaging plays an important role in safely distributing products throughout today's society and supply chains. With a consumption of about 40% of plastics and 50% of paper in Europe, the packaging sector is a large user of materials. Packaging has a lot of environmental impacts, while it also represents a significant cost in the current supply system. Reusable packaging has been suggested as an option to significantly reduce environmental impacts. Coelho, P. M., Corona, B., ten Klooster, R., & Worrell, E. (2020). Sustainability of reusable packaging-Current situation and trends. Resources, Conservation & Recycling: X, 100037.	**Accepted.** Sentence included "Strategies of reducing the environmental impact of packaging include using less/more sustainable materials and a shift to re-usable packaging concepts (Coelho et al. 2020). "	Mariel Vilella	Zero Waste Europe/University of Manchester	United Kingdom (of Great Britain and Northern Ireland)
46235	56	25	57	25	Please add after the last sentence: ‘In recent years, due to restrictions for high GWP-refrigerants, a considerably growth in the market availability of appliances and systems with those natural, i.e. non-fluorinated refrigerants has taken place (Eckert 2021).’ Eckert, M.; Kauffeld, M., Siegismund, V. (2021): Natural Refrigerants: Applications and Practical Guidelines, VDE-Verlag, shecco SPRL, Brüssel 2021, ISBN 978-3-8007-5330-7 (Published in German as Natürliche Kältemittel: Anwendungen und Praxiserfahrungen (2019), ISBN: 9783922420620)	**Accepted.**Sentence included.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
22229	56	33	56	33	for the statement "may require a lower energy investment during manufacture" it also require land	**Accepted.** Sentence extended "[…], but may require larger land area and can generate methane […]"	Government of France	Ministère de la Transition écologique et solidaire	France
70605	56	34	56	37	: sentence unclear: "food packaging system"? Or "food system"	**Editorial.** Food system	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
57877	56	36	56	36	"packaging can account for only 1-12% of the GHG emissions ... of a food packaging system." Perhaps it should be "food processing system?"	**Editorial.** It should be "Food system"	Government of United State	U.S. Department of State	United States of America
5549	56	40	56	40	replace Renewables" by "low carbon sources"	**Accepted**. Changed to low-carbon energy sources.	Michel SIMON	Retraité/ Pdt d'association	France
61863	56	40	56	40	"[..] the use of heat and electricity from renewable energy sources [..]". Rephrase "renewable energy" into "low-carbon energy" to be scientifically more accurate, consistent with climate mitigation and technology neural.	**Accepted**. Changed to low-carbon energy sources.	Rauli Partanen	Think Atom	Finland

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
65903	56	40	56	40	"[..] the use of heat and electricity from renewable energy sources [..]". Rephrase "renewable energy" into "low-carbon energy".	**Accepted**. Changed to low-carbon energy sources.	Eero Hirvijoki	Aalto University	Finland
57879	57	22	57	23	Define "GWP" as "Global Warming Potential (GWP)"	**Rejected.** GWP is used earlier in the Chapter.	Government of United State	U.S. Department of State	United States of
57881	57	33	58	24	This section does not appear to have a point -- particularly with respect to GHG mitigation. It merely describes some global food system scenarios people have used or proposed. This section could be deleted with no loss to the chapter.	**Accepted.** Due to space limitations, we have considerably shortened this section and integrated the (remaining) part into the introduction.	Government of United State	U.S. Department of State	United States of America
57883	57	34	57	36	Incorrect that the SSP scenarios only model changes in food demand due to population and GDP. SSP1 is designed explicitly to represent a transition to a more sustainable diet, lower in animal products.	**Noted.** Due to space limitations we have considerably shortened this section. The sentence has been deleted.	Government of United State	U.S. Department of State	United States of America
57885	58	8	58	8	"where mostly poor suffers" should be "where mostly the poor suffer"	**Noted.** Due to space limitations we have considerably shortened this section. The sentence has been deleted.	Government of United State	U.S. Department of State	United States of America
22233	58	9	58	13	Suggestion to add : comparison of legumes substitution in diet and in feed supply (Prudhomme et al 2020) https://link.springer.com/article/10.1007%2Fs10113-020-01651-4	**Accepted**. Reference added - paragraph moved to the introduction, see comment #57881	Government of France	Ministère de la Transition écologique et solidaire	France
22231	58	10	58	11	Suggestion add the following reference ; Hedenus et al., 2014 https://link.springer.com/article/10.1007/s10584-014-1104-5	**Accepted**. Reference added - paragraph moved to the introduction, see comment #57881	Government of France	Ministère de la Transition écologique et solidaire	France
57887	58	17	58	17	"proposal" should be "proposed"	**Editorial**	Government of United State	U.S. Department of State	United States of
22235	58	19	58	20	An article exists, based on the Agrimonde-Terra foresight: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0235597	**Accepted**. Reference added - paragraph moved to the introduction, see comment #57881	Government of France	Ministère de la Transition écologique et solidaire	France
57889	58	19	58	20	Article mismatch between "a" and "narratives"	**Editorial.** Sentence rewritten	Government of United State	U.S. Department of State	United States of
57891	58	19	58	21	Citation(s) needed.	**Accetped**. Sentence rewritte and references added.	Government of United State	U.S. Department of State	United States of
57893	58	24	58	24	Rather than "utilization and stability" perhaps "diet and food security?"	**Noted.**Due to the shortening of this section (see comment #57881) the sentence is not part of the FDG	Government of United State	U.S. Department of State	United States of America
57895	58	25	58	38	This section does not appear to have a point -- particularly with respect to GHG mitigation. It merely states that some things ""must"" happen but does not say why. For example, why ""must"" food policies be transformative. Similarly why ""must"" food policies address consumers' lack of awareness of the environmental impact of food choices or build acceptance of novel food technologies. Suggest toning down the text a bit.	**Accepted.** The paragraph has been re-written avoiding prescriptive statements and making the link to GHG mitigation explicit.	Government of United State	U.S. Department of State	United States of America
86791	58	25			It should be noted that not all food systems must be transformed to be sustainable, as recognized by the competent fora (FAO Council and Programme Committee, 2020), and there is a need to avoid this kind of generalizations not based on sound scientific evidence.	**Accepted.** The paragraph has been re-written avoiding prescriptive statements and making the link to GHG mitigation explicit.	Government of Argentina	Ministry of Environment and Sustainable development of Argentina	Argentina
57897	58	26	64	20	The text of Section 12.4.5 mentions GHG mitigation once (with respect to the most effective mitigation measure being reducing red meat consumption in wealthy countries). Numerous other worthy goals and objectives are discussed but the emphasis is on sustainability, equity, and some yet precisely articulated vision of transformation. The text should have something about GHG mitigation in each subsection.	**Accepted.** The paragraph has been re-written avoiding prescriptive statements and making the link to GHG mitigation explicit. See details at comment #57895	Government of United State	U.S. Department of State	United States of America
57899	58	35	58	43	Two statements make policy recommendations. Rephrase or delete.	**Accepted.** This part has been re-written	Government of United State	U.S. Department of State	United States of
22237	58	39	58	39	in this section, the impact of policies on companies' behaviour is missing. When a policy is put in place, in addition to affecting consumer behavior, companies may also respond by, for example, changing their product recipes to limit the negative impact of the policy on their profits. This may follow the introduction of a tax, or information (such as nutri-score, or yuka application). The literature review navigates between nutritional and environmental issues without linking the two. These two pillars of sustainability are not necessarily aligned and the question of a common policy or, more modestly, the impact of a nutritional policy on the environment and vice versa is not addressed here. The complementarity/substitutability of nutritional and environmental issues is important for the construction of policies and their impacts. - There is nothing about the dietary recommendation tools that flourish on smartphones, which are essentially private initiatives (such as Yuka). In general, digital tools allow for a personalization of food policies that is not discussed at all in this chapter.	**Rejected.** The section assesses the full range of policies including regulatory and market-based policies that target companies in the food processing and retail sector. Also food labels are assessed (and Nutri-Score already explicitly mentioned in the SOD).	Government of France	Ministère de la Transition écologique et solidaire	France
57901	58	40	58	43	Specify "evidence-based" instruments.	**Noted.** This part has been re-written, see comment 57899.	Government of United State	U.S. Department of State	United States of
57903	58	44	59	3	The report discusses "market-based instruments" in the context of agricultural and fishery policies. Not all agricultural and fishery policies are "market based," so this needs to be clarified.	**Accepted**. Text has been modified - this statement has been deleted in view of word limitations.	Government of United State	U.S. Department of State	United States of America
86839	58	44	58	46	With regards to the mention that "Relevant market based instruments include agricultural and fishery policies (see Chapter 7), trade policies, and taxes and subsidies with the intention of improving public health and/or reducing the environmental impact of the food system", there is a need to add at the end of the phrase: ",ALL MEASURES WHICH MUST BE CONSISTENT WITH WTO RULES", as all market-based instruments in agricultural and fisheries sector must be compliant with the WTO Agreements, given their trade implications, and that must not constitute uneccessary barriers to international trade nor create distortions to agricultural production and trade.	**Rejected.** The IPCC refrains from prescriptive statements; the sentence is purely descriptive. However, this sub-section has been completely rewritten and the sentence deleted.	Government of Argentina	Ministry of Environment and Sustainable development of Argentina	Argentina
86793	59	4			The concept "sustainable diets" has not been agreed upon in the competent multilateral fora, so its scope is unclear. We sugget removing it.	**Accepted.** We have modified and use the term 'Sustainable healthy diets' as defined by FAO and WHO (2019) throughout the section.	Government of Argentina	Ministry of Environment and Sustainable development of Argentina	Argentina
57905	59	9	59	15	The first paragraph under the section "Market based instruments" is a run-on sentence. The entire paragraph needs to be revised.	**Accepted**. Paragraph has been merged with following paragraphs while considerably shortening.	Government of United State	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
57907	59	22	59	22	"Measurable effects ... are seen above 20% increases found to be effective ..." What?	**Accepted.** Sentence changed to "Subsidies and taxes are found to be effective in changing the dietary behaviour of consumers at levels above 20% (Niebylski et al. 2015; Mozaffarian et al. 2018; Nakhimovsky et al. 2016; Cornelsen et al. 2015; Hagenaars et al. 2017), even though longer term effects are scarcely studied (Cornelsen et al. 2015) and effects of sugar tax with tax rates lower than 20% have been observed for low-income groups (Temme et al. 2020)."	Government of United State	U.S. Department of State	United States of America
57909	59	25	59	25	Quantify "lower tax rate". Lower than 20%?	**Accepted.** Sentence changed to "Subsidies and taxes are found to be effective in changing the dietary behaviour of consumers at levels above 20% (Niebylski et al. 2015; Mozaffarian et al. 2018; Nakhimovsky et al. 2016; Cornelsen et al. 2015; Hagenaars et al. 2017), even though longer term effects are scarcely studied (Cornelsen et al. 2015) and effects of sugar tax with tax rates lower than 20% have been observed for low-income groups (Temme et al. 2020)."	Government of United State	U.S. Department of State	United States of America
82865	59	31	59	33	I'm confused by how increasing flows which then reduces global prices and increases global demand leads to a potential reduction of GHG emissions. Seems like the opposite would be true.	**Accepted.** Sentence has been clarified. Not emissions are reduced but mitigation effects.	Raychel Santo	Johns Hopkins Center for a Livable Future	United States of America
86841	59	31	59	35	With regards to the mention that "Unilateral taxes on food with high GHG intensities have been shown to induce increase net export flows which could reduce global prices and increase global demand; indirect effects on GHG emissions therefore could be reduced by up to 70-90% of national mitigation results (Zech and Schneider 2019;Fellmann et al. 2018) (limited evidence, high agreement). Global mitigation potential for GHG taxation of food products at 52 USD kgCO2-eq-1 has been estimated at 1 GtCO2-eq yr-1 35 (Springmann et al. 2017)", we suggest its deletion, as there is no multilateral consensus on these conclusions, and are only based on secondary literature without sound scientific evidence. In addition, taxes based on GHG intensities could be inconsistent with WTO rules, as they would lead to a discrimination among similar products.	**Rejected.** The sentences describe results of studies.	Government of Argentina	Ministry of Environment and Sustainable development of Argentina	Argentina
86843	59	36	59	37	With regards to the mention to "Taxes have the potential to improve the nutritional quality of diets and reduce GHG emissions from food system", we suggest deleting the phrase "and reduce GHG emissions from food system", as there is no scientific evidence that this is the case, while this affirmation has no multilateral consensus, as expressed above.	**Accepted.** This reports from results of studies, which has been clarified in the sentence.	Government of Argentina	Ministry of Environment and Sustainable development of Argentina	Argentina
81731	60	6	60	16	As above, suggest include a narrative here on how there is evidence of reforming subsidies and supporting and enabling trade system can improve environmental outcomes i.e. there are several OECD reports outline the potential harmful negative impacts of trade distorting subsidies, including the 2020 report “The Economic and Environmental Impacts of Climate Change and Trade Liberalisation on the Agricultural Sector”.	**Noted.** Positive effects of trade on Sustainability is assessed in the previous paragraph (lines 59/42-60/5 in SOD).	Government of New Zealand	Ministry for the Environment	New Zealand
86845	60	11	60	14	With regards to the phrase "GHG mitigation efforts in food supply chains can be counteracted by GHG leakage, with a general increase of environmental and social impact in developing countries, and a decrease in the developed countries of consumption (Wiedmann and Lenzen 2018; Sandström et al. 2018; Fellmann et al. 2018)", we suggest its deletion as the concept for GHG leakage in food supply has no sound basis, and the idea posed in this sentence is based on secondary literature that has no multilateral agreement.	**Rejected**. The concepte of emission leakage is well established	Government of Argentina	Ministry of Environment and Sustainable development of Argentina	Argentina
57911	60	18	60	18	What is meant by a "disconnection between consumption and food chain and primary production"?	**Accepted.** This was unclear and has been deleted	Government of United State	U.S. Department of State	United States of
28789	60	26	60	29	What are the five research areas the InterAcademy Partnership identified in their assessment?	**Accepted.**The assessments were on opportunities and challenges on food and nutrition security in the different continents.	Erin Biehl	Johns Hopkins Center for a Livable Future	United States of America
22239	60	32	60	40	Should it be discussed here the issue of the prevalence in developing countries of many industrialised edible products (such as margarine) packaged in sachet-sized presentations (a few g), which estimulate their consumption by the poorest sector of the population (due to affordable unitary prices)?	**Noted**. The text already points towards the problem of high consumption of products high in saturated fats, trans-fatty acides, free sugars and salt.	Government of France	Ministère de la Transition écologique et solidaire	France
57913	60	34	60	34	"encounter" should be "counter"	**Editorial**	Government of United State	U.S. Department of State	United States of
57915	60	34	60	36	"They aim to [counter]" and what was endorsed?	**Editorial.** The 'aim to counter'…'was endorsed'. Sentence corrected	Government of United State	U.S. Department of State	United States of
86795	61	1	61	4	Please remove the reference to non multilaterally agreed terms ("green public procurement" and "sustainable products"). Additionally, please avoid biased concepts throught the list of examples provided (i.e. the reference to "Maetless Monday" as an example unsustainable products demand reduction policies).	**Rejected.** Green Public Procurement is a term that is used in literature and policies. Additional references have been added.	Government of Argentina	Ministry of Environment and Sustainable development of Argentina	Argentina
57917	61	2	61	3	Citation needed for Copenhagen example.	**Accepted**. Reference added.	Government of United State	U.S. Department of State	United States of
57919	61	4	61	6	Unclear what is meant by "... to improve dietary choices and depending on the organizational context, organizations can increase ..."	**Accepted**. Due to space limitations additional explicatory text not added and 'depending on the organizationsl context' has been deleted	Government of United State	U.S. Department of State	United States of America
22241	61	21	61	25	See eg. of Directive (UE) 2018/851on waste : the Member states have to reduce the generation of food waste in primary production, in processing and manufacturing in retail and other distribution of food, in restaurant and food services as well as in households (art.9)	**Noted**. This directive says that legislation should be in place by MS. It is not a 'mandatory food regulation' referred to in the text.	Government of France	Ministère de la Transition écologique et solidaire	France
28791	61	21	61	21	Is this supposed to say "There only few mandatory food waste regulations"? The paragraph is specifically about food waste, and I think it's incorrect that those are the only regulations on food.	**Accepted.** Sentence has been reformulated to clarify that this is only an example for possible regulations.	Erin Biehl	Johns Hopkins Center for a Livable Future	United States of America
57921	61	23	61	25	2020 is over. Were the targets achieved?	**Accepted.** As we do not yet have information if the target was achieved the target year was deleted from the sentence (as not relevant for the content of the sentence).	Government of United State	U.S. Department of State	United States of America
70607	61	26	61	26	is the abbreviation VSS useful? It is only used once after	**Accepted.** VSS not used	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
57923	61	28	61	28	"borne" rather than "beard"	**Editorial**	Government of United State	U.S. Department of State	United States of

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
70609	61	28	61	32	the examples given do not seem to illustrate the fact that"the certification of a certain scheme can be costly and generally beard by the producers"	**Accepted**. The examples referred to Voluntary sustainability standards and not to them being costly. Paragraph has been re-arranged.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
57925	61	42	61	42	Unclear what is meant by "... are constructed out of health consideration and only few so are mentioning ..."	**Accepted.** Replaced with 'based on'.	Government of United State	U.S. Department of State	United States of America
57927	61	45	61	45	Does this mean only a few FBDGs have given recommendations for vegetarian diets, at various levels of detail?	**Accepted.** Yes.	Government of United State	U.S. Department of State	United States of America
57929	61	46	61	46	"recommendation" should be "recommendations"	**Editorial**	Government of United State	U.S. Department of State	United States of
81737	62	4	62	6	This sentence references the EAT Lancet Healthy Reference Diet (Willet et al, 2019). We suggest it is important to add the following sentence to highlight the multiple issues and criticisms of the proposed EAT-Lancet diet regarding both nutritional and environmental sustainability aspects: "However a number of questions have been raised by different authors about both the nutritional and environmental sustanability implications of the EAT Lancet Healthy Reference Diet. For example, Zagmutt et al (2019) conclude that omissions in the EAT Lancet documentation, together with methodological flaws in assumptions, data collection, and modelling, are substantial enough to alter the conclusions of the report; Vanham et al (2020) raise concerns regarding sustainable water use in the context of the EAT Lancet reference diet; and Zagmutt et al (2020) conclude that the EAT-Lancet Commission's Dietary Composition May Not Prevent Non-communicable Disease Mortality." Suggest referencing: https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(19)31903-8/fulltext#seccestitle10 And: Davy Vanham, Mesfin M. Mekonnen, Arjen Y. Hoekstra, Treenuts and groundnuts in the EAT-Lancet reference diet: Concerns regarding sustainable water use, Global Food Security, Volume 24, 2020, 100357 And: Francisco J Zagmutt, Jane G Pouzou, Solenne Costard, The EAT-Lancet Commission's Dietary Composition May Not Prevent Noncommunicable Disease Mortality, The Journal of Nutrition, Volume 150, Issue 5, May 2020, Pages 985–988, https://doi.org/10.1093/jn/nxaa020	**Accepted.** The sentence has been extended including those concerns and references.	Government of New Zealand	Ministry for the Environment	New Zealand
86797	62	5	62	6	We suggest removing the reference to concepts which are not broadly accepted nor have been multulaterally discussed, such as "planetary health diet".	**Rejected.** This is the term used in the reference given. We have added 'so-called' for clarification	Government of Argentina	Ministry of Environment and Sustainable development of Argentina	Argentina
86799	62	7			Same as previous comments on the term "sustainable diets". We suggest deleting it.	**Accepted.** We have modified and use the term 'Sustainable healthy diets' as defined by FAO and WHO (2019) throughout the section.	Government of Argentina	Ministry of Environment and Sustainable development of Argentina	Argentina
22243	62	12	62	13	We suggest to complete with : "or the arbitrary belief in the environmental superiority of organic or local produce." E.g.: Suciu NA, Ferrari F, Trevisan M (2019) Organic and conventional food: Comparison and future research. Trends Food Sci Technol 84:49–51. https://doi.org/10.1016/j.tifs.2018.12.008 Edwards-Jones G, Milà i Canals L, Hounsome N, et al (2008) Testing the assertion that “local food is best”: the challenges of an evidence-based approach. Trends Food Sci Technol 19:265–274. https://doi.org/10.1016/j.tifs.2008.01.008	**Rejected.** The environmental effect of organic agriculture is multi-faceted and cannot be treated properly in a half-sentence. The reference given discusses only nutritional qualities and GHG emissions, not the environmental effect in its entirety. The concepts of 'local food' and 'food miles' are very similar thus no change required.	Government of France	Ministère de la Transition écologique et solidaire	France
70611	62	28	62	28	the multiplication of labels tends to compromise their contribution to transparency and develops scepticism about their interest among consumers	**Accepted**. Sentence deleted, as was also redundant with first sentence in paragraph.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
57931	63	8	63	9	"[do] not normally" and what is the default option in this context?	**Accepted**. Sentence clarified. "making the sustainable option the default option"	Government of United State	U.S. Department of State	United States of America
86801	63	14			Same as previous comments on the term "sustainable diets". We suggest deleting it.	**Accepted.** We have modified and use the term 'Sustainable healthy diets' as defined by FAO and WHO (2019) throughout the section.	Government of Argentina	Ministry of Environment and Sustainable development of Argentina	Argentina
57933	63	19	63	20	Article mismatch between "a" and "packages"	**Editorial**	Government of United State	U.S. Department of State	United States of
57935	63	23	63	23	"eases" should be "ease"	**Editorial**	Government of United State	U.S. Department of State	United States of
57937	63	27	63	27	"... governed by [separate policy areas]"?	**Editorial**	Government of United State	U.S. Department of State	United States of
57939	63	36	63	36	"areas, bearing the risk of" should be "areas and the risk"	**Editorial**	Government of United State	U.S. Department of State	United States of

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
57941	64	1	64	1	What is an example of transformation that starts out as niche and becomes rapid change?	**Noted**. The corresponding texts from the citated papers are: "Lifestyle choices such as veganism, vegetarianism and flexitarian- ism are experiencing rapid growth in developed economiesviii. Consumer preferences for food that has been produced locally or for which provenance is clear have also increasedix. Whilst these trends are certainly niche, they are reinforced by growing awareness of the links between diet, health and the environment. [...] Growing awareness of climate risks in the financial sector is lead- ing to new risk management approaches, new disclosure require- ments and the emergence of 'no go' sectors such as coal,x whilst sustainable finance products and instruments such as green investment funds and green bonds are experiencing rapid growth. Given that the food system accounts for almost a third of green- house gas emissions and is a primary driver of biodiversity loss and pollution, it is likely to become an increasing focus of innov- ation in financial governance and products. These emerging niches are clearly mutually reinforcing, so should they reach sufficient scale then transformation to an effi- cient food system could occur rapidly." (Benton and Bailey, 2019). "This theory argues that when a committed mi- nority reaches a critical group size—commonly referred to as a "critical mass"—the social system crosses a tipping point. Once the tipping point is reached, the actions ofaminority group trigger a cascade ofbehavior change that rapidly increases the acceptance of a minority view (12–14). The simplest formulation of critical mass theory maintains that small groups of regular individuals—that is, with the same amount of social power and resources as everyone else— can successfully initiate a change in social con- ventions. According to this view, the power of small groups comes not from their authority or wealth but from their commitment to the cause (14, 15)." (Jasny, 2018)	Government of United State	U.S. Department of State	United States of America
86803	64	3	64	5	Replace "is the most effective single measure" for "is a measure", otherwise remove the sentece.	**Rejected**. The evidence in the literature is very strong. The sentence has been slighly modified by replacing 'the most effective single measure' by amongst the most effective measures' though the previous sentence reflects evidence from literature which has been included. "Reduction of excess meat (and dairy) consumption in affluent countries is amongst the most effective measures to mitigate GHG emissions with a high potential of co-benefit for environment, health, food security, biodiversity, and animal welfare (Stylianou et al. 2021; Willett et al. 2019; Chai et al. 2019; Chen et al. 2019; Hamilton et al. 2021; Hedenus et al. 2014; Kim et al. 2020; Semba et al. 2020; Springmann et al. 2018; Theurl et al. 2020) (robust evidence, high agreement). "	Government of Argentina	Ministry of Environment and Sustainable development of Argentina	Argentina
57943	64	10	64	10	Should "reduction" be "consumption"?	**Editorial**	Government of United State	U.S. Department of State	United States of
86805	64	10	64	16	The paragraph is biased as it conveys a wrong message on the nutritional and environmental impacts of meat production and consumption. We suggest its deletion.	**Accepted.** Sentence has been modified and reads now 'However, behavioural change towards diets of lower environmental impact and higher nutritional qualities faces barriers both from agricultural producers, and consumers (Milford et al. 2019; Aiking and de Boer 2018; de Boer et al. 2018; Apostolidis and McLeay 2016) [...]'	Government of Argentina	Ministry of Environment and Sustainable development of Argentina	Argentina
10031	65	1			Row 1 of Table 12.10 'Assessment of food system policies --- consumers' can be presented in a nicer way.	**Accepted.** Table 12.10 has been thoroughly revised.	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
57945	65	1	68	3	There is only a vague reference to Table 12.10 on page 64, in the last paragraph. This table is hard to read and interpret; therefore, it should either be removed or the authors should discuss the table in more detail.	**Accepted.** Additional discussion of the Table added. Also, the table and the corresponding text has been moved to the introductory part of Section 12.4.5 (in FDG 12.4.4) to better embed the content of the table with the following sub-sections assessing the single options more in depth.	Government of United State	U.S. Department of State	United States of America
70613	65	1	67	3	the table is so long that it would ease reading if the explanations at the beginning of page 67 were moved to the beginning of the table	**Accepted.** Table 12.10 has been thoroughly revised.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
57947	68	1	80	18	The section discussing land is incomplete. Recommend inclusion of supporting references listed, and to ensure this concept is incorporated: The synergies and benefits that accrue from conserving and improving management of existing forests, including immediate GHG savings at lower cost, far exceed the much riskier costs and benefits of afforestation. References: Frances Seymour. 2020. Seeing the Forests as well as the (Trillion) Trees in Corporate Climate Strategies https://doi.org/10.1016/j.oneear.2020.05.006. Lewis, S.L., Wheeler, C.E., Mitchard, E.T.A., and Koch, A. (2019). Restoring natural forests is the best way to remove atmospheric carbon. Nature 568, 25-28. Goldstein, A., Turner, W.R., Spawn, S.A., Anderson-Teixeira, K.J., Cook-Patton, S., Fargione, J., Gibbs, H.K., Griscom, B., et al. (2020) Protecting irrecoverable carbon in Earth's ecosystems. Nat. Clim. Chang. 10, 287-295.	Taken into account. As for other land-based mitigation, forest conservation and improved forest management - including both benefits and risks - are covered in Ch7. This section covers in a complementary way land related impacts, risks and opportunities associated with mitigation options that change land use.	Government of United State	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
57949	68	1	80	18	The discussion of land cover and emissions from ""land use change"" should be reviewed to include more balanced description of root causes for emissions from deforestation and LUC, and opportunities to reduce those emissions through policies governing agriculture new infrastructure, mining, fossil fuel development, and other activities that open frontier lands to settlement. Deforestation and anthropogenic fires are related to inequality and governance, including massive subsidies for agriculture and ""development"" of new frontiers in nations that still have relatively large, intact forest estates. Clearing is more often not about market demand to feed people, but a product of need for impoverished, greed of well-off, and opportunities presented by local land tenure and development policies -- for example, subsidies in the USA for corn and soy growers reached new highs in 2020, and a total of US$46.3 billion was paid to farmers in subsidies (USDA https://data.ers.usda.gov/reports.aspx?ID=17833). Subsidies around the globe retain a lot of inefficient land in agricultural activities, and other subsidies continue to expand clearing in the name of ""development"". See, for example: Kline and Dale 2020; https://www.osti.gov/pages/biblio/1735411 26; IJESNR 26(4) doi:10.19080/IJESNR.2020.26.556194. Eigenbrod et al. 2020 Identifying Agricultural Frontiers for Modeling Global Cropland Expansion https://doi.org/10.1016/j.oneear.2020.09.006	Noted. This section covers risks and opportunities from implementation of mitigation responses that occupy (new) land ie change land use (although we include changes that are not recognised as LUC in GHG inventories - see #57951). The potential for displacement of previous land use, causing iLUC, is mentioned. Broader consideration of LUC drivers is out of scope. Drivers of land use change are discussed in 7.3.1.	Government of United State	U.S. Department of State	United States of America
57951	68	12	68	12	Line 12 refers to "land occupation". What is that? Any use by humans of a land area? Isn't this typically referred to as land use or land use change?	We use "land occupation" rather than "land use" because the latter is ambiguous in the context of climate policy. We use land occupation to refer to the land required for deployment of mitigation strategies. In some instances these strategies constitute a recognised land use change (e.g. conversion from cropland to forest land), but we also use the term where this is not the case such as where land is occupied by a hydro dam or solar panels. These latter do not consistute a "land use" according to usage in national GHG inventories, though they might satisfy the more generic definition also provided in the IPCC glossary entry for the term "land use".	Government of United State	U.S. Department of State	United States of America
57953	68	14	68	20	The second paragraph is unnecessary, because the information is presented below. Delete it.	Accepted. Introduction condensed, par deleted	Government of United State	U.S. Department of State	United States of
57955	68	22	68	22	It is not clear what "context conditions" means. Possibly drop the word "context".	Accepted. reworded as "contextual factors "	Government of United State	U.S. Department of State	United States of
57957	68	31	68	33	There is a list of factors that will affect the GHG savings. Societal systems are mentioned but there is no mention of market systems.	Noted. "societal systems" was intended to include markets. Markets are now explicitly mentioned "including technical infrastructure and markets" Note that this text has been moved to the section on Afforestation/Reforestation, as the introduction has been condensed.	Government of United State	U.S. Department of State	United States of America
57959	68	33	68	37	It is unclear if this sentence is reflective of forest science. It seems to state that very little is known about forest carbon, with agricultural biomass production being the only ecosystem biomass production even remotely understood. With over a century of forest biomass production research establishing a lot of tenets such as self-thinning, allometry, etc., this just isn't true. The literature as been focused in temperate systems but alot of gains have occurred in Asia, Southeast Asia, and Africa.	Accepted. Sentence deleted	Government of United State	U.S. Department of State	United States of America
57961	68	35	68	35	It is not clear what broader sustainable development impacts are being referred to in this section.	Accepted. Sentence deleted	Government of United State	U.S. Department of State	United States of
57963	68	37	68	37	Regarding agricultural biomass, see: https://www.ers.usda.gov/publications/pub-details/?pubid=81902	Noted. Introduction condensed, sentence deleted	Government of United State	U.S. Department of State	United States of America
52577	68	38			Such impacts on the land should be included in the SPM	Noted; the potential to include the land-footprint of other mitigation options in the SPM will be discussed amongst the SPM drafting authors and subject to further government review comments on the SPM.	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
57965	69	7	69	7	Should "requirement as much" be "requirement for food as much"?	Accepted: changed as proposed	Government of United State	U.S. Department of State	United States of
57967	69	13	69	13	Capitalize "Assessment" and "Models"	Accepted: changed as proposed	Government of United State	U.S. Department of State	United States of
77641	69	13	69	26	The statement that “IAM’s do not capture more subtle changes in land management and in the associated industrial/energy systems due to limited representation of land quality and feedstock/management practices and of institutions, governance and local context.”is very important as there are clear differences in risk of loss and premature release of GHG to the atmosphere associated with differences in forest condition. The FAO has released a new report that enables identification of Earths most substantial, resilient and stable forest carbon stocks ie primary forests (A Review of Definitions, Data and methods for Country level rAssessment and Reporting of Primary Forst, March 2021)	Noted. We have shared the information about this FAO publication with Ch7 which covers the AFOLU sector	Virginia Young	Australian Rainforest Conservation Society	Australia
57969	69	15	69	15	What is the definition of "variable electricity generation"?	Noted. Since SOD it has been decided to use "variable renewable energy sources". In this specific place, we decided to change to "wind and solar".	Government of United State	U.S. Department of State	United States of America
73915	69	19			The work by 'Rose et al.' is under submission.	Noted. This publication was not accepted before cut-off date so citation has been deleted.	Raehyun KIM	National Institute of Forest Science	Republic of Korea
73917	69	19			The work by 'Calvin et al' is under subimission.	Noted. Paper now acepted and citation updated	Raehyun KIM	National Institute of Forest Science	Republic of Korea
73919	69	24			The work by 'Calvin et al' is under subimission.	Noted. Paper now acepted and citation updated	Raehyun KIM	National Institute of Forest Science	Republic of Korea
22245	69	25	69	26	This line of reasoning does not take into account that BECCS plants may prioritise energy crops as a source of biomass either for energy efficiency reasons or for an easier access, as opposed to biomass generated by forest maintenance or agriculture	Accepted, point added.	Government of France	Ministère de la Transition écologique et solidaire	France

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61865	69	27	69	40	In discussing land occupation, there should be mention that nuclear energy, on the per-produced-energy basis, occupies by far the least land of all low-carbon energy sources as shown in Fig.12.9. This is a significant benefit that nuclear energy has in regards to environmental footprint and should be mentioned.	Accepted, point added.	Rauli Partanen	Think Atom	Finland
65905	69	27	69	40	In discussing land occupation, there should be a mention of nuclear energy which, on the per-produced-energy basis, occupies the least land of all low-carbon energy sources as shown in Fig.12.9. The paragraph should explicitly mention that nuclear energy is the least-land-intensive option of the clean energy sources, by almost two orders of magnitude.	Accepted, point added.	Eero Hirvijoki	Aalto University	Finland
57971	69	33	69	33	Define "power density" if this is the first time it's used.	Accepted, definition added.	Government of United State	U.S. Department of State	United States of
57973	69	36	69	40	These sentences discuss backup of wind and solar with hydropower and biomass, but make no mention of fossil fuels, such as natural gas, commercial scale battery storage of electricity which is becoming more feasible due to new technologies, or the time needed and cost of transitioning from the existing electricity system to the system described. They mention distributed generation such as rooftop solar but do not discuss the potentially limited electricity availability and lower reliability of these systems as compared to traditional grid-based electricity. If this paragraph is referring to specific model output in these sentences, that should be made clearer in the text.	Accepted. Sentence changed to: "Reservoir hydropower and biomass based dispatchable power can complement other balancing options (e.g., battery storage, grid extensions and demand-side management to provide power stability and quality needed in power systems with large amounts of variable electricity generation from wind and solar power plants." We consider this sentence also responds to the comment about potentially limited electricity availability and lower reliability of these systems as compared to traditional grid-based electricity. In the revised sentence, we refer to Ch6 for information on these issues.	Government of United State	U.S. Department of State	United States of America
57975	70	1	70	4	The authors mention floating solar PV in hydropower dams, followed by a reference to agricultural and forestry residues for bioenergy. Residues are a commonly used source of biofuels and can scale up to provide a large source of bioenergy, while floating solar PV is not a cost-effective technology widely adopted at commercial scale and its ability to scale is limited or unknown. It should be made clear in the report whether the authors are discussing an existing technology or a potential technological innovation. One is a known with known costs; the other is unknown.	Accepted. Sentence reworded to indicated floating solar on hydro dams is a novel strategy.	Government of United State	U.S. Department of State	United States of America
57977	70	1	70	4	The authors state that bioenergy use from existing agricultural and forest residues will not require additional land use. This is untrue and ignores the underlying market mechanisms that will drive producer behavior if bioenergy becomes a valuable source of fuel. Farmers will face a trade-off between providing agricultural products for food or for bioenergy. The extent to which agricultural residues are expanded by agricultural products that could have been provided in food or feed will be determined in part by the relative prices in these markets. In addition, the amount of residue removed from the field affects the soil quality for subsequent plantings and the amount of fertilizer that is required in production. Finally, the amount of land used in growing food, feed, and bioenergy will vary based on relative prices in these markets. Decisionmaking regarding the amount of agricultural and forestry residues used for bioenergy will not be restricted to land that is already used for crops or forestry. Section 12.5.2.1 discusses the risks of biomass extraction, but not the role of markets or prices.	Taken into account. Organic waste and residues represent a source of biomass that can be sourced from land that is already used. Possible impacts of such uses, e.g., declining soil productivity, are covered later in 12.5. Nevertheless, we have revised the text to acknowledge that land owners consider economic factors when making decisions. The following is now stated: "There are also situations where expanding mitigation is more or less decoupled from additional land use. The use of organic consumer waste, harvest residues and processing side-streams in the agriculture and forestry sectors can support significant volumes of biobased products with relatively lower land-use change risks than dedicated biomass production systems.	Government of United State	U.S. Department of State	United States of America
57979	70	1	70	13	Most roundwood facilities use over 99% of the timber products they receive. Byproducts may be sold for downstream product or, as identified, used as a power source. These facilities are quite efficient because margins are thin. How much biomass power could be sold back? Perhaps the analysis is found elsewhere but as written there is not enough information presented to understand whether this option would contribute much.	Noted. Modern large sawmills have high efficiency, but there is room for improvement in many smaller mills and other biomass processing facilities such as sugar mills. We do not have capacity to expand text on this due to word limits.	Government of United State	U.S. Department of State	United States of America
10033	70	14			The quality of 'Figure 12.9 Box plots of power densities --- Source: (van Zalk and Behrens 2018)' can be improved.	Noted. Figure has been deleted.	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
57981	70	14	70	15	The figure provides critical information about the trade-offs between fossil fuel and renewable generation based on the power density. It is discussed only briefly and should either be described in more detail or excluded.	Accepted. Figure has been deleted.	Government of United State	U.S. Department of State	United States of America
57983	70	14	70	21	Figure 12.9 is misleading and misinformative. Power density is not the appropriate functional unit and the graph attempts to compare apples to oranges to nuclear reactors. For example, oil may appear to have high density but fracking for oil and gas has effects yet to be determined, and exploration activities and seismic lines (without producing a drop of oil) open new virgin forests, even parks and protected areas, to human incursion and damage. Furthermore, the power density numbers distract from what matters: How land is managed in terms of carbon and nutrient cycles, emissions, and other services. Delete the figure.	Accepted. Figure has been deleted.	Government of United State	U.S. Department of State	United States of America
61867	70	14	70	20	In Figure 12.9, nuclear energy is grouped together with coal, oil, and natural gas, which seems strange given that it is low-carbon energy source and has the smallest land and materials footprint of all energy sources (indeed, making it the energy source with the overall smallest environmental footprint). The grouping should instead be fossil and non-fossil or, alternatively, carbon intensive and low-carbon, placing nuclear into the same group with renewables. Please change the graph or colour coding accordingly.	Noted. Figure has been deleted.	Rauli Partanen	Think Atom	Finland
65907	70	14	70	20	In the figure 12.9, grouping nuclear energy together with coal, oil, and natural gas, is rather implicative. The grouping should instead be fossil and non-fossil or, alternatively, carbon intensive and low-carbon, placing nuclear into the same group with renewables. Change the color coding accordingly. After all, it is the carbon emissions that matter.	Noted. Figure has been deleted.	Eero Hirvijoki	Aalto University	Finland
51201	70	16	70	20	"Figure 12.9 Box plots of power densities for different energy options": people correlate power density with land use. The correlation is essentially correct except, some people contend, for wind energy. Those people claim that the "lost" land area (the land area locked away from other uses only a small fraction of the surface area of the wind farm. It may be worth reminding that in the caption.	Noted. Figure has been deleted.	Eric PROUST	European Nuclear Society (ENS)	France

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
57985	70	23	70	27	In Section 12.5.2, there is a descriptive sentence highlighting the impacts and trade-offs of land use changes but, once again, market impacts are not mentioned. Both the potential for market mechanisms, such as prices, or market based policies such as taxes or cap and trade to incentivize consumers and producers to move towards mitigation and the costs of mitigation are key. Consumers and producer decisions in markets will have a huge influence over how land will be reallocated in order to mitigate climate change, yet they are not discussed.	Noted. Section 12.5.3 porvides qualitiative discussion on risks, impacts and opportunities of land-based mitigation. Governance approaches are disucsed in 7.6.	Government of United State	U.S. Department of State	United States of America
11945	71	3	17	3	land as resource included in the narrative is related to economic activities for energy generations, mitigation etc while the ones that have become redundant due to mining, abandoned stone quarries, brick kilns among others often at the discretion of geo-political decisions as most of these now are strategically located in mega cities and with high land valves' add to climate risks and impacts. Also geo-political decisions to boost the economic activities on fertile land often on the immediate periphery of mega cities sacrificed for setting up factories at the costs of food security, environment, local ecosystem and carbon rather than exploring other small and medium towns; especially among developing nations.	Noted. This comment refers to the sub-heading "Risks and impacts, and their mitigation". It is not clear to us what, if any, changes the reviewer proposes. We have therefore not made any changes in direct response to the comment	Anjali Sharma	Research, Projects and Collaborative initiatives, Delhi.	India
57987	71	4	72	44	Section 12.5.2.1, under the subheading Land, includes several paragraphs discussing the pros and cons of switching from the current grid-based electricity generation in much of the world which uses largely fossil fuels (i.e., coal, nuclear, and natural gas) to a world where electricity generation is from modern renewable sources. A reorganization to focus on land changes related to the energy sector would improve the section.	Noted. The section has been restructured to consider in turn each of the mitigation options	Government of United State	U.S. Department of State	United States of America
77643	71	9	71	33	This section could benefit from examination of the innovative landscape scale approach developed by Morgan et to achieve multiple objectives (Integrating forest management across the landscape: a three pillar framework, Morgan, Cadman & Mackey, Journal of Environmental Planning and Management 2020). It is a thoughtful approach based on case studies in very different political and social contexts and offers an effective way to meet community, governance, climate mitigation, adaptation, development and ecosystem integrity goals.	Accepted. Citation added	Virginia Young	Australian Rainforest Conservation Society	Australia
57989	71	11	71	11	How realistic is broadscale annual forest biomass cropping?	Noted. This section refers to annual (non-woody) bioenergy crops, and contrasts the opportunities from perennial grassses and woody crops.	Government of United State	U.S. Department of State	United States of America
57991	71	16	71	26	The discussion of monoculture plantations highlights the risks of this form of agriculture, but suggests that mitigation can be done by using energy crops for food or feed instead of soybean, but ignores consumer preferences entirely and the feasibility of altering people's diets. If energy crops were meant to substitute for soybean that is used for something other than food or feed, that should be clarified. The paragraph also indicates that energy crop systems can be designed to enhance ecosystem outcomes, but does not discuss the potential loss of efficiency and increased costs of moving away from a monoculture system.	Noted. We have clarified that we are referring here to cultivation of protein feed for livestock	Government of United State	U.S. Department of State	United States of America
57993	71	27	71	33	Citation needed.	Noted. Sentence has been deleted due to word limit.	Government of United State	U.S. Department of State	United States of
81725	71	31	71	33	Suggest recognising that different species of trees sequester carbon at different rates. So A/R of "some" species that will ensure carbon sequestration from 50 - 150 years time is an appropriate action to take. Suggest also recognising that cultural factors play a huge role in determining what species are planted and for what purpose. In New Zealand our Māori land owners want to restore their land to pre-colonial tree cover and for them planting of species to sequester and store carbon is a valid option to take. In most cases the new forests are going on land that is unproductive (steep and remote) so little forestry industry can take place.	Taken into account. We are here discussing potential for A/R to cause indirect deforestation. The situation described in this comment would not lead to indirect deforestation. Integrated landscape approaches should ideally consider all relevant local environmental and socio-economic objectives.	Government of New Zealand	Ministry for the Environment	New Zealand
57995	71	34	71	34	The authors refer specifically to the visual impacts of wind turbines when discussing the land impacts, but it's not clear why visual impacts are highlighted. There are also noise impacts.	Accepted. Noise added.	Government of United State	U.S. Department of State	United States of America
57997	71	34	72	11	In the discussion of the deployment of renewable energy, the section does not differentiate between grid-based and distributed electricity. The costs of these two types of electricity are different and vary dramatically across countries. For instance, in Nigeria, grid-based power is unreliable and distributed solar solutions may be more cost-effective and importantly reduce reliance on diesel-fueled generators. In developed countries, grid-based electricity is more reliable so the opportunity cost of distributed solar (i.e., solar panels on roofs) is higher.	Noted. Out of scope for 12.5. Review comment forwarded to ch6 authors.	Government of United State	U.S. Department of State	United States of America
74251	71	38	71	40	This section should be revised to also include the impacts on migrating insects from wind farms. https://docs.wind-watch.org/Interference-of-Flying-Insects-and-Wind-Parks.pdf	Accepted. Insects now mentioned, and citation to recent journal paper added.	Jeffrey Merrifield	Pillsbury Law Firm	United States of America
57999	71	40	71	41	The authors state that painting blades can reduce mortality from wind turbines, but they fail to mention that the largest improvements in mortality reduction have been from siting turbines. For wind farm siting, see: Manville, A.M., II. 2009. Towers, turbines, power lines, and buildings -- steps being taken by the U.S. Fish and Wildlife Service to avoid or minimize take of migratory birds at these structures. In C.J. Ralph and T.D. Rich (editors). Proceedings 4th International Partners in Flight Conference, February 2008, McAllen, TX. and https://www.sciencedirect.com/science/article/pii/S0301479717306436.	Accepted. Importance of siting added, with recent journal paper citation.	Government of United State	U.S. Department of State	United States of America
22247	71	41	71	41	word missing: "mortality due to collision"	Accepted. Word added.	Government of France	Ministère de la Transition écologique et solidaire	France

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
22297	71	41	71	43	Please note that (i) solar PV uses much more land areas than the low-carbon nuclear power that must also be considered (see for instance Figure 12.9) and that (ii) the fact that solar PV uses less land that wind power very much depends how is counted the surface needed for wind farms. Indeed, agriculture is very much possible together with wind farms so that the « lost » area is very much smaller than the total area of the wind farm. It is not so for solar PV (except if on rooftops but then more expensive) Vasilis Fthenakis, Hyung Chul Kim, Land use and electricity generation: A life-cycle analysis, Renewable and Sustainable Energy Reviews,Volume 13, Issues 6–7,2009,Pages 1465-1474,ISSN 1364-0321, https://doi.org/10.1016/j.rser.2008.09.017	Noted. The land occupation of nuclear, wind and solar are discussed. The difference between solar and wind with respect to co-location with agriculture is discussed.	Government of France	Ministère de la Transition écologique et solidaire	France
58001	71	41	71	44	The discussion of solar installations fails to mention the numerous micro solar installations in the developing world, particularly in India and parts of Africa. It also fails to note the various options for micro solar in agriculture. These distributed applications are discuss later in Section 12.5. Possibly reorganizing Sections 12.5.2.1 and 12.5.2.2, which both cover the mitigation options for solar, would provide more consistency.	Noted. The section has been restructured to consider each of the mitigation strategies in turn	Government of United State	U.S. Department of State	United States of America
61869	71	41	71	43	"Solar thermal and PV power installations can lock away land areas from other uses. However, these use less land per unit of energy output than most other non-fossil options." As the topic is discussed, it should be mentioned that nuclear energy has by far the smallest environmental footprint of all the low-carbon energy sources, as clearly shown in Fig 12.9.	Accepted. Land occupation of nuclear, solar and wind are discussed in 12.5.1.1	Rauli Partanen	Think Atom	Finland
65909	71	41	71	43	"Solar thermal and PV power installations can lock away land areas from other uses. However, these use less land per unit of energy output than most other non-fossil options." What are the 'other non-fossil options'? As clearly shown in Fig 12.9, nuclear has the smallest land occupation per produced energy of all low-carbon technologies. This should be explicitly mentioned in the given context. Revise accordingly.	Accepted. Land occupation of nuclear, solar and wind are discussed in 12.5.1.1	Eero Hirvijoki	Aalto University	Finland
51203	71	42	71	43	"Solar thermal and PV power installations can lock away land areas from other uses. However, these use less land per unit of energy output than most other non-fossil options". Wrong: it is not true that "solar thermal and PV power installations use less land than most other non-fossil options": they are using a lot more land than wind and nuclear. For nuclear, this is obvious from Figure 12.9. For wind, power density is not indivative of land area lowed away from other uses, indeed most of the surface area of a wind firm can used for agricultural purposes.This is not the case for solar farms (right, this is the case of solar PV on rooftops but this option is more expensive and intrinsically limited)	Accepted. Land occupation of nuclear, solar and wind are discussed in 12.5.1.1	Eric PROUST	European Nuclear Society (ENS)	France
58003	71	45	71	41	In the discussion of siting solar farms in the desert, there is no discussion of the costs of transmission.	Noted. Challenges for power distribution are mentioned.	Government of United State	U.S. Department of State	United States of America
61225	71	45	71	47	What is the basis? There are also desert areas in the middle latitude regions.	Noted. Sentence modified to clarify that solar farms are particularly well-suited to deserts in low latitudes due to high global horizontal irradiance	Jianguo WU	chinese research academy of environmental sciences	China
22249	72	5	72	5	Concerning the "local heat island effect" , the "heat" effect of wind turbine is poorly described here. Wind turbine limites the very cold layer of air near the surface. So that it is not realy a "local heat" but rather a "reduced cold"	Accepted. Sentence modified to avoid reference to "heat island": "wind turbines could lead to warmer night temperatures due to atmospheric mixing"	Government of France	Ministère de la Transition écologique et solidaire	France
61227	72	9	72	11	Further increase the literature and evaluate the situation in other regions	Noted. No specific literature suggested. Sentence modified to clarify that Sahara is an example.	Jianguo WU	chinese research academy of environmental sciences	China
18849	72	12	72	12	We are missing the reference on the accident related with mining for nuclear. In case there is none we suggest to erase the mention because of fact that every mining operation has its own risks.	Accepted. Citations added to support this sentence.	Tomáš Martanovič	Ministry of Industry and Trade	Czech Republic
22251	72	12	72	12	Concerning the statement "risks associated with mining operations" , is that a fact ? What have been the accidents linked to mining operations for nuclear, and ar these significant compared to those for other industries ?	Accepted. Citations added to support this sentence.	Government of France	Ministère de la Transition écologique et solidaire	France
31503	72	12	72	12	"Nuclear power has... risks associated with mining operations": What are the significant accidents related to uranium mining operations comparing with other mining operations or oil extractions sites ?	Accepted. Citations added to support this sentence.	Carolina Ahnert	Universidad Politécnica de Madrid	Spain
51205	72	12	72	12	"Nuclear power has... risks associated with mining operations": what facts make it worth mentioning theses risks? What are the significant accidents related to mining operations? Are they more significant than those encountered in other industries?	Accepted. Citations added to support this sentence.	Eric PROUST	European Nuclear Society (ENS)	France
58005	72	12	72	25	In the discussion of nuclear power, the authors fail to note that a large risk associated with nuclear power is disposal of used fuel rods. There is technology being developed to reuse fuel rods, but it is currently cost-prohibitive. Also, deployment of new nuclear power generation has huge costs and is likely not feasible in large parts of the developing world. In the discussion of the benefits of the Chernobyl exclusion zone, it should seem that the benefits of biodiversity (aren't there genetic mutations in that biodiversity) is overstated. What about the loss of life, human and other species, from the nuclear accident? And the permanent exclusion of any other land use in that area is a huge cost. It should also be noted that nuclear power relies on fuel that is not renewable. Lastly, there is a public perception that nuclear energy is dangerous, particularly after the Fukushima accident and that would need to be overcome to deploy nuclear-generated electricity on a larger scale.	Partly accepted. The focus of this section is land impacts of deployment. Land requirement for disposal is now mentioned.	Government of United State	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
61871	72	12	72	13	"Nuclear power has land impacts and risks associated with mining operations, but the land occupation is small compared to many other mitigation options (Figure 12.9)." According to Figure 12.9 nuclear has by far the smallest land occupation of all non-fossil energy sources. Further, it has a much smaller materials need than wind and solar (by roughly an order of magnitude, as can be seen by comparing EPR, Supplementary Table 1 in Vidal et al., 2013, https://doi.org/10.1038/ngeo1993 and median estimates for wind and solar from Carrara et al 2020, http://dx.doi.org/10.2760/160859). This implies that wind and solar will have roughly 10 times the impact regarding mining operations compared to nuclear (not including REE's and uranium which have similar pattern). Logically, it should be mentioned that wind and solar have roughly ten times higher risks associated with mining operations compared to nuclear power.	Accepted. Land requirement for mining of critical minerals for wind and solar now mentioned. Carrara et al cited.	Rauli Partanen	Think Atom	Finland
65911	72	12	72	13	"Nuclear power has land impacts and risks associated with mining operations, but the land occupation is small compared to many other mitigation options (Figure 12.9)." This is a rather pessimistic view. First, according to Figure 12.9, nuclear has the smallest land occupation of all non-fossil energy sources, by almost two orders of magnitude. Second, nuclear energy has the smallest material footprint of all non-fossil enrgy source, by an order of magnitude. In this context, it seems implicative that "mining operations" are mentioned explicitly for nuclear but for other non-fossil technologies. Either remove this excerpt entirely or add similar mining statements to the assessments of other energy sources as well.	Accepted. Land requirement for mining of critical minerals for wind and solar now mentioned. Carrara et al cited.	Eero Hirvijoki	Aalto University	Finland
24701	72	13	72	20	It should be noted that nuclear is not the only power producing technology to have been responsible for accidents. We therefore question the level of detail into which this section goes about Chernobyl in order to use it to illustrate that nuclear could have large land impacts. In our opinion, either other technologies which have faced comparable accidents are subjected to the same level of treatment (eg Banqiao dam failure) or this example is removed.	Accepted. Failure of hydropower dams now mentioned.	Ann Jessica Johnson	FORATOM (European Atomic Forum)	Belgium
61873	72	13	72	20	The paragraph discusses the single worst nuclear accident, which occurred on a soviet-design reactor the type of never built in the west (an important distinction regarding the safety of nuclear in the future). Similar accounts on other accidents should be provided for context, e.g. the Banqiao dam failure, which resulted in 85000-204000 deaths. "Contaminated" is mentioned several times but not quantified nor qualified in any meaningful way, nor put it in context. For example, there are only a few dozen confirmed fatalities due to radiation from the Chernobyl accident (see United Nations Scientific Committee on the Effects of Atomic Radiation, UNSCEAR, https://www.unscear.org/unscear/en/chernobyl.html). Wildlife thrives in the exclusion zone due to human absence (Deryabina et al., 2015, https://doi.org/10.1016/j.cub.2015.08.017; Lerebours et al., 2018, https://doi.org/10.1021/acs.est.8b02378; UNEP https://www.unep.org/news-and-stories/story/how-chernobyl-has-become-unexpected-haven-wildlife).	Accepted. Failure of hydropower dams now mentioned. (Biodiversity impacts were already discussed, inlcuding the suggested reference Deryabina.)	Rauli Partanen	Think Atom	Finland
65913	72	13	72	20	The paragraph is a rather detailed account of the single worst nuclear accident, yet there are no similar detailed accounts on, e.g., the worst hydropower accident, the Banqiao dam failure, which resulted in estimated 85000-204000 deaths. In comparison, it would be fair to mention studies that show how wildlife now flourishes even in the Chernobyl Exclusion Zone, largely due to absence of human activity (Deryabina et al., 2015, https://doi.org/10.1016/j.cub.2015.08.017 ; Lerebours et al., 2018, https://doi.org/10.1021/acs.est.8b02378 ; UNEP https://www.unep.org/news-and-stories/story/how-chernobyl-has-become-unexpected-haven-wildlife).	Accepted. Failure of hydropower dams now mentioned. (Biodiversity impacts were already discussed, inlcuding the suggested reference Deryabina.)	Eero Hirvijoki	Aalto University	Finland
22253	72	14	72	15	We recommand to replace "As an example," with: "As an extreme accident," because this accident is the worst case to date, and it cannot be representative of the impacts of each nuclear power reactor. It should be highlighted and justified why extreme accidents and their consequences (including number of death) are only mentioned for nuclear power (dam failures are also significant impacts).	Accepted. Wording changed to refer to Chernobyl as an extreme example. Failure of hydropower dams now mentioned.	Government of France	Ministère de la Transition écologique et solidaire	France
31505	72	14	72	25	"As an example, the 1986 Chernobyl accident …". This accident may not be consider an example, it was one exceptional accident.	Accepted. Wording changed to refer to Chernobyl as an extreme example.	Carolina Ahnert	Universidad Politécnica de Madrid	Spain
51207	72	14	72	25	"As an example, the 1986 Chernobyl accident …". NO, this is not "an exemple" among others, this is THE WORST nuclear accident ever whose consequences are very much larger than any other one (one order of maginitude more radioactivity released than the second worst accident, Fukushima where furthermore, less than 20% of the released radioactivity was deposited on land [1]) [1] Georg Steinhauser, Alexander Brandl & Thomas E. Johnson, Comparison of the Chernobyl and Fukushima nuclear accidents: A review of the environmental impacts, Science of The Total Environment, Volumes 470–471, 2014, Pages 800-817, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2013.10.029.	Accepted. Wording changed to refer to Chernobyl as an extreme example.	Eric PROUST	European Nuclear Society (ENS)	France
4131	72	18			change to 'people were relocated away from these areas'	Accepted	Jane McAdam	University of New South Wales	Australia

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
76643	72	20	72	25	These sentences are rather unsettling and potentially misleading as they implicitly present the loss of land due to contamination as being somehow compensated by the creation of a biosphere reserve that could represent an asset to enhance biodiversity and carbon storage. The presence of an abundant mammal community due to the absence of human beings in the zone should not conceal largely documented impacts of radiation to fauna and flora, including morphological, physiological and genetic disorders. All major taxonomy groups investigated by Møller and Mousseau in highly radioactive areas of the exclusion zone displayed reduced population size and species richness. See : - Mousseau T, Møller, A, 2014, Genetic and Ecological Studies of Animals in Chernobyl and Fukushima, Journal of Heredity, Volume 105, Issue 5, September-October 2014, Pages 704–709, https://doi.org/10.1093/jhered/esu040 - Mousseau T, Møller, A, 2020, Plants in the Light of Ionizing Radiation: What Have We Learned From Chernobyl, Fukushima, and Other “Hot” Places?r, Frontier Plant Science. | https://doi.org/10.3389/fpls.2020.00552 - See also Nesterenko, AV ; Nesterenko, VB ; Yablokov, AV, 2009, Chernobyl: consequences of the catastrophe for people and the environment, Annals of the New York Academy of Sciences, 1181 DOI: 10.1111/j.1749-6632.2009.04819.x) Furthermore, considering contaminated areas as a tool to manage carbon stock would and thus a mitigation option would be paradoxical. Chernobyl forests are actually significantly more prone to forest fires, as the reduced presence of soil invertebrates due to radiations results in poor wood decomposition and accumulation of dry wood and litter (See Møller AP, Mousseau TA. Reduced colonization by soil invertebrates to irradiated decomposing wood in Chernobyl. Sci Total Environ. 2018 Dec 15;645:773-779. doi: 10.1016/j.scitotenv.2018.07.195. Epub 2018 Jul 19. PMID: 30031335.). In addition to that, the contamination level makes it more difficult for firemen to step in. This already resulted in major forest fires in 2010 and 2020, with the destruction last year of 470 km2.	Partly accepted. Impacts on invertebrates and plants now menitoned and two of the proposed citations added	Charlotte MIJEON	Réseau "Sortir du nucléaire" (organiszation affiliated to the French Climate Action Network)	France
22255	72	26	72	26	Concerning "reservoir hydropaower", It could seem surprising that this page mentions at length the consequences of nuclear accidents, but does not do so for the consequences of dam failures that have been significant.	Accepted. Failure of hydropower dams now mentioned.	Government of France	Ministère de la Transition écologique et solidaire	France
31507	72	26	72	34	""Hydropower reservoirs …"": What about the risk of dams failure ?	Accepted. Failure of hydropower dams now mentioned.	Carolina Ahnert	Universidad Politécnica de Madrid	Spain
51209	72	26	72	34	"Hydropower reservoirs …": While the preceding paragraphe devotes 13 lines to the risks associated with nuclear accidents with a lengthy description of the consequences of the worst ever nuclear accident, there is not a single word in this section about the risks associated with dam failures. This double standard is all the more surprising that the cumulative death toll associated with dam failures is considerably higher than the one associated with nuclear accidents. Allow me to recall that the Banqiao dam failure in 1975 resulted in the death toll estimated between 26 000 (the official Chinese figure [1]) and 230 000 [2], at least between one and two orders of magnitude larger that the death toll of the Chernobyl accident. [1] Yao Xu ; Limin Zhang ; and Jinsheng Jia, Lessons from Catastrophic Dam Failures in August 1975 in Zhumadian, China, GeoCongress 2008, https://doi.org/10.1061/40971(310)20 [2] Si Yi, The World’s Most Catastrophic Dam Failures: The August 1975 Collapse of the Banqiao and Shimantan Dams. Chapter 3 of: Qing, D., Thibodeau, J.G., Topping, A.R., Dai, Q., Yi, M., & Williams, M.R. (1998). The River Dragon Has Come!: Three Gorges Dam and the Fate of China's Yangtze River and Its People: Three Gorges Dam and the Fate of China's Yangtze River and Its People (1st ed.). Routledge. https://doi.org/10.4324/9781315502779 The content of this chapter is also reported in https://u.osu.edu/mclc/2019/02/18/dam-collapse-that-china-kept-secret/	Accepted. Failure of hydropower dams now mentioned.	Eric PROUST	European Nuclear Society (ENS)	France
22257	72	30	72	30	The sentence "a loss of C sequestration by growing vegetation in the flooded area." would need a clearer rephrasing	Accepted, reworded for clarity	Government of France	Ministère de la Transition écologique et solidaire	France
4133	72	35			replace ‘entail’ with ‘necessitate’	Accepted, Reworded as proposed	Jane McAdam	University of New South Wales	Australia
4135	72	36			change to ‘and affect downstream’	Accepted, Reworded as proposed	Jane McAdam	University of New South Wales	Australia
4137	72	37			Change to: ‘Displacement as well as relocation/resettlement schemes can have significant social, economic, psychological and environmental consequences (McAdam and Ferris 2015; Cernea 2000), including those associated with establishment of new agricultural land.’ References cited here are: Jane McAdam and Elizabeth Ferris, ‘Planned Relocations in the Context of Climate Change: Unpacking the Legal and Conceptual Issues’ (2015) 4(1) Cambridge Journal of International and Comparative Law 137; Michael M Cernea, ‘Risks, Safeguards, and Reconstruction: A Model for Population Displacement and Resettlement’ in Michael M Cernea and Christopher McDowell (eds), Risks and Reconstruction: Experiences of Resettlers and Refugees (World Bank 2000).	Rejected. Not relevant to this section, which focuses on impacts on land resources and ecosystem services.	Jane McAdam	University of New South Wales	Australia
4139	72	39			change to ‘Dam construction may also stimulate migration into the affected region’	Accepted. Proposed change made.	Jane McAdam	University of New South Wales	Australia
78253	73	2	73	3	Unspecific - "Negative impacts on aquatic systems can occur due to 3 chemical and thermal pollution loading." is without reference and may be removed.	Noted. References added.	Reetesh Chaurasia	Department of Atomic Energy, Government of India	India

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
58007	73	6	73	14	The discussion of water used in biomass production mentions rainfed, but does not include a discussion of irrigated energy crops. In order to increase the acres available for and the volume of biomass production per acre, irrigation may be required.	Accepted. Sentence on irrigated energy crops added.	Government of United State	U.S. Department of State	United States of America
77645	73	6	73	14	while the statement about the impact of using logging residues for bioenergy on water supply may be correct. Logging itself has an impact on both water supply and water quality. Moreover very little actual residue is ever economic to collect which is why residues are conveniently defined to include whole trees that have no other market or for which bioenergy offers a higher return. How this new market driver impacts which forests become economic to log and how they are logged is completely missing from analysis in chapter 7. Increasing the frequency of logging rotations and shifting the marginal cost of wood production, encourages higher rates and increased area of logging. The impacts of this relatively new driver on logging practices in existing forests (and related impacts on water, biodiversity and stable long term carbon storage) need much more careful evaluation! (Ajani??)	Noted. This section covers risks and opportunities from implementation of mitigation responses that occupy (new) land ie change land use (although we include changes that are not recogbnised as LUC in GHG inventories - see #57951). The potential for displacement of previous land use, causing iLUC, is mentioned. This section does not cover management of existing forests, which is addressed in Chapter 7.	Virginia Young	Australian Rainforest Conservation Society	Australia
12105	73	15	73	29	Suggest the addition on a note that temperature, albedo and precipitation locally and regionally can be effected by the planting of large forests, changes that, if planting is done at sufficient scale, can mitigate or enhance the effects of climate change in the affected areas (Griscom et al., 2017) and evidence suggests that such changes will not be trivial (Winckler, 2019, Luyssaert, 2018). LUYSSAERT, S. M., GUILLAUME: VALADE, AUDE: CHEN, YI-YING: NJAKOU DJOMO, SYLVESTRE: RYDER, JAMES: OTTO, JULIANE: NAUDTS, KIM: LANSØ, ANNE SOFIE: GHATTAS, JOSEFINE: MCGRATH, MATTHEW J. 2018. Trade-offs in using European forests to meet climate objectives. Nature, 562, 259-262. GRISCOM, B. W., ADAMS, J., ELLIS, P. W., HOUGHTON, R. A., LOMAX, G., MITEVA, D. A., SCHLESINGER, W. H., SHOCH, D., SIIKAMÄKI, J. V., SMITH, P., WOODBURY, P., ZGANJAR, C., BLACKMAN, A., CAMPARI, J., CONANT, R. T., DELGADO, C., ELIAS, P., GOPALAKRISHNA, T., HAMSIK, M. R., HERRERO, M., KIESECKER, J., LANDIS, E., LAESTADIUS, L., LEAVITT, S. M., MINNEMEYER, S., POLASKY, S., POTAPOV, P., PUTZ, F. E., SANDERMAN, J., SILVIUS, M., WOLLENBERG, E. & FARGIONE, J. 2017. Natural climate solutions. Proceedings of the National Academy of Sciences, 114, 11645-11650 WINCKLER, J. L.,REICK, Q., PONGRATZ, J., 2019. Nonlocal Effects Dominate the Global Mean Surface Temperature Response to the Biogeophysical Effects of Deforestation. Geophysical Research Letters, 46, 745-755	Accepted. Sentence added on regional climate effects of large-scale plantings. There is limited evidence that very large-scale land use or vegetation cover changes can alter regional climate and precipitation patterns, e.g., downwind precipitation depends on upwind evapotranspiration from forests and other vegetation (Keys et al. 2016; Ellison et al. 2017; van der Ent and Tuinenburg 2017)	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
58009	73	15	73	15	"influence the" should be "influence on the"	Accepted, thanks	Government of United State	U.S. Department of State	United States of
58011	73	15	73	29	Good to see the potential issue that arises between trees for carbon and water quantity/quality.	Noted, no change required.	Government of United State	U.S. Department of State	United States of
77649	73	28	75	33	This paragraph is misleading. Ending deforestation and forest degradation has immediate, medium and long-term mitigation benefits - permanently improving and maintaining the integrity and stability of existing natural forests is critical for the health of the biosphere. Carbon stored in our largest and most stable carbon stocks (primary forests) followed by restoration of long unlogged natural forests, has the best chance of permanence. However, ensuring they persist requires increased conservation action to buffer and reconnect vulnerable forests, reduce fragmentation and edge effects and encourage ecological restoration to improve the resilience and resistance of existing primary and other natural forests, thereby maximising the integrity of restoration efforts and protection of existing carbon dense primary forests. Only by doing so can we reduce the impact of threats that will increase with climate change - threats which are much greater (and will increase with climate change) for large-scale monoculture, AR and young regrowth forests. Where ever feasible fostering regeneration of secondary forests and allowing them to reach their biological and carbon carrying potential will improve their overall integrity and stability and must be prioritised over planting new trees including bioenergy tree crops. Growing wood on farms in agro ecological systems will likewise become increasingly important for long term stable wood supply (Understanding the importance of primary tropical forests as a mitigation strategy, Mackey et al, Mitigation and Adaptation Strategies for Global Change, 2020; Intact forests in the United States: proforestation mitigates climate change and serves the greatest good, Moomaw et al Frontiers for Global Change 2019)	Accepted. Text on avoided deforestation, forest restoration expanded; proposed citations added.	Virginia Young	Australian Rainforest Conservation Society	Australia
58013	73	30	73	39	The discussion of perennial plants in agriculture fails to indicate how these plants would be integrated. If agricultural land is planted in perennial plants, there are costs in terms of lost acreage for feed, food, or energy crops and potential costs in terms of the amount of capital and labor required to farm a landscape that is intersected by perennial plants.	Accepted. We have now added specific examples to the text (riparian buffers, contour planting, changes in crop rotation patterns to increase cultivation of ligno grasses and legumes). Cited literature provides examples of integrated biomass production systems. We have also added a sentence acknowledging that block planting may be preferred from logistical perspective. See also Cross-Working Group Box in 12.5: Mitigation and Adaptation via the Bioeconomy.	Government of United State	U.S. Department of State	United States of America
29713	73	31	73	33	Please check if this sentence is complete.	Accepted. Sentence reworded	Government of Norway	Norwegian Environment Agency	Norway
58015	73	31	73	33	Missing verb in this sentence.	Accepted. Sentence reworded	Government of United State	U.S. Department of State	United States of

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
77647	73	31	73	39	With the exception of BOX 12.1, which goes some way towards acknowledging the role of innovative approaches to landscape scale restoration and regeneration, Chapter 7 has paid little attention to the growing movement promoting connectivity conservation and agricultural regeneration, perhaps because the published literature has yet to reflect the scale at which 'connectivity conservation' initiatives are now operating. Landscape connectivity programmes exist across the globe, all of which involve to a greater or lesser extent fostering large-scale, multi-stakeholder restoration and regeneration activities including of forests, other natural ecosystems and regenerative agriculture on farms. These initiatives deliver multiple benefits for climate mitigation, adaptation, biodiversity and farm productivity. They are mostly based around permanent recovery of native vegetation (forests) and improvements to on farm productivity and offer superior and cost effective prospects of long term increases in carbon sequestration and permanent storage – moving way beyond neutrality! (The Nexus Report: Nature Based Solutions to the Biodiversity and Climate Crises, Barber C.V, Petersen R., Young V, Mackey B, Kormos C, 2020: Gondwanlink.org; ger.org.au). Morgan et al (2020) have developed an innovative framework for achieving landscape scale multiple objectives in a complementary manner (Integrating forest management across the landscape: a three pillar framework, Morgan, Cadman, Mackey, Journal of Environmental planning and management). Note that neutrality will not reverse the biodiversity crisis and that if we fail to do so ecosystems will continue to decline and collapse with or without climate change. Degradation and collapse poses a hidden terror for both climate mitigation and adaptation and provision of all ecosystem services on which humanity is dependent. Mitigation options that are biodiversity positive must be prioritised if we are to successfully tackle climate change in any time frame but the options for doing so are shrinking and urgent (IPBES 2019; Bergstrom et al, Combating ecosystem collapse from the tropics to Antarctic, Global Change Biology, 2021).	Accepted. Text on restoration expanded to mention landscape connectivity and need for planning and strong governance. Morgan et al citation added.	Virginia Young	Australian Rainforest Conservation Society	Australia
58017	74	1	74	1	This figure is not well-described in the text and is unnecessary. The previous paragraph that refers to the figure could also be omitted or placed in another section as it does not flow with the text in this section. Delete them both.	Accepted. Par reworded to improve flow. Figure (12.10) will be modified.	Government of United State	U.S. Department of State	United States of America
58019	74	4	74	15	The reference to anaerobic digestion is too brief. It is not clear what technologies are being referred to, their availability in markets, and their cost. In general, it should be made clear when the text is referring to a technology that is in wide use or a technology that is not yet available or in use.	Noted. Status as mature technology has been added. Due to word limits we cannot expand further.	Government of United State	U.S. Department of State	United States of America
80709	74	5	74	12	Note that manure additives have shown potential to reduce CH4 and N2O emissions (Peterson et. al., 2019; Ross, 2020). CITATIONS: Peterson, C., et. al. (2020). Effects of SOP Lagoon Additive on Gaseous Emissions from Stored Liquid Dairy Manure, Sustainability 12: 1–17, 12 ("Compared to the CONT, the HIGH treatment achieved average emission reductions of 22.7% and 14.7% for CH4 and CO2, respectively ($p < 0.05$). The HIGH vs CONT treatment also showed an emission reduction of 45.4% for N2O."). Ross E. G., et. al. (2020) Effect of SOP "STAR COW" on Enteric Gaseous Emissions and Dairy Cattle Performance, Sustainability 12(24): 1–12, 1 ("The aim of this study was to investigate the efficacy of the commercial feed additive SOP STAR COW (SOP) to reduce enteric emissions from dairy cows and to assess potential impacts on milk production. … SOP-treated cows over time showed a reduction in CH4 of 20.4% from day 14 to day 42 ($p = 0.014$), while protein % of the milk was increased (+4.9% from day 0 to day 14 ($p = 0.036$) and +6.5% from day 0 to day 42 ($p = 0.002$).").	Rejected. The cited studies are not relevant to management of methane emissions from anaerobic digestion.	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America
80853	74	5	74	12	Note that manure additives have shown potential to reduce CH4 and N2O emissions (Peterson et. al., 2019; Ross, 2020). CITATIONS: Peterson, C., et. al. (2020). Effects of SOP Lagoon Additive on Gaseous Emissions from Stored Liquid Dairy Manure, Sustainability 12: 1–17, 12 ("Compared to the CONT, the HIGH treatment achieved average emission reductions of 22.7% and 14.7% for CH4 and CO2, respectively ($p < 0.05$). The HIGH vs CONT treatment also showed an emission reduction of 45.4% for N2O."). Ross E. G., et. al. (2020) Effect of SOP "STAR COW" on Enteric Gaseous Emissions and Dairy Cattle Performance, Sustainability 12(24): 1–12, 1 ("The aim of this study was to investigate the efficacy of the commercial feed additive SOP STAR COW (SOP) to reduce enteric emissions from dairy cows and to assess potential impacts on milk production. … SOP-treated cows over time showed a reduction in CH4 of 20.4% from day 14 to day 42 ($p = 0.014$), while protein % of the milk was increased (+4.9% from day 0 to day 14 ($p = 0.036$) and +6.5% from day 0 to day 42 ($p = 0.002$).").	Rejected. The cited studies are not relevant to management of methane emissions from anaerobic digestion.	Gabrielle Dreyfus	Institute for Governance & Sustainable Development	United States of America
43249	75	3	75	7	This sentences about pyrolysis are speculative and have no reference so they should be deleted or contrasted with other literature about the current development of pyrolysis: what's clear so far is that higher-temperature technologies, such as pyrolysis and gasification, have yet to achieve commercial success (Tangri & Wilson, 2017). Tangri, N., & Wilson, M. (2017). Waste Gasification & Pyrolysis: High Risk, Low Yield Processes for Waste Management. GAIA.	Rejected. Citations and cross-reference to chapter 7 added. Pyrolysis is deployed at large scale in China, and growing elsewhere.	Mariel Vilella	Zero Waste Europe/University of Manchester	United Kingdom (of Great Britain and Northern Ireland)
11871	75	19	75	27	The definition of what perennial crops means, is it 2,3, or more years in order not to lose productivity. What is gain under the growing period can be lost in the breaking process to a new culture by higher GHG emissions. The same goes for perennial grain crops were the yielding and productivity must be evaluated better before this solution gives a lower carbon footprint versus intensive controlled cropping with annual varieties.	Noted. We cannot expand due to word limits. The section has been revised to focus on mitigation options that involve a change in land use; the sentence on perennial grains has been deleted.	The Royal Swedish Academy	Kung. Skogs-och Lantbruksakademien	Sweden
58021	75	28	75	33	Avoided deforestation and degradation can indeed help meet short-term goals. However, it's not clear why these areas are separated from the longer term solution of forest management. It would seem that the areas where investments are made in avoided deforestation/degradation would be better served with continued forest management to support the use of wood in long-term products.	Noted. Forest conservation and improved forest management - including both benefits and risks - are covered in Ch7. This section covers risks and opportunities assocaited with mitigation options that change land use (noting also response to #57951)	Government of United State	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
58023	75	34	75	34	The statements on biodiversity benefits seem contrary to statements made elsewhere in the chapter.	Noted. We are not sure what inconsistncy the reviewer perceives. Possibly it is that elsewhere we say there is a tradeoff between in-forest carbon and biodiversity, but that refers to the contrast between natural and managed forests whereas here we talk about A/R on agricultural land.	Government of United State	U.S. Department of State	United States of America
79261	75	45	76	10	The blanket statement that C stocks in native vegetation planted to improve ecosystem integrity are more vulnerable to loss through disturbance is deeply puzzling given that is contradicted by ecological science (see publication by the Ecogical Restortaion Society) , IPBES 2019 and the Millenium Ecosystem Assessment 2005. A good example is provided by native vegetation planted as part of rconnectivity ecovery efforts in Western Australia which have proven far more resilient to fire than monoculture plantings in the same region (Gondwanlink.org). Many native ecosystems have evolved to cope with variation in external conditions including extremes.	Rejected. The reviewer may have misunderstood the contrast being drawn. As stated, this text contrasts the mitigation benefit of A/R activites that sequester carbon in forests with the mitigation benefit of activiteis that displace fossil fuel emissions or sequester carbon in building materials. There is no doubt that the carbon stored in forests is more vulnerable to loss than carbon in fossil fuels that remain in the ground, or carbon in wood building products, and end of life wood products in landfill.	Virginia Young	Australian Rainforest Conservation Society	Australia
58025	75	46	75	46	The terms rehabilitation and restoration are introduced on page 75, but not defined until page 77.	Accepted. Cross reference to Box 12.1 has been expanded to clarify that this is where the definitions of these terms are found.	Government of United State	U.S. Department of State	United States of America
80695	75	46	76	5	Biomass substitution for fossil fuels is not an effective mitigation strategy because burning forest biomass for power generation emits more CO2 per unit of final energy than burning fossil fuels. Mary S. Booth, Not carbon neutral: Assessing the net emissions impact of residues burned for bioenergy, Environ. Res. Lett. 13 (21 February 2018); Sterman J. D., et al. (2018) Does replacing coal with wood lower CO2 emissions? Dynamic lifecycle analysis of wood bioenergy, Envtl. Research Letters 13(015007):1–10, 1 ("We simulate substitution of wood for coal in power generation, estimating the parameters governing NPP and other fluxes using data for forests in the eastern US and using published estimates for supply chain emissions. Because combustion and processing efficiencies for wood are less than coal, the immediate impact of substituting wood for coal is an increase in atmospheric CO2 relative to coal. The payback time for this carbon debt ranges from 44–104 years after clear-cut, depending on forest type—assuming the land remains forest. Surprisingly, replanting hardwood forests with fast-growing pine plantations raises the CO2 impact of wood because the equilibrium carbon density of plantations is lower than natural forests. Further, projected growth in wood harvest for bioenergy would increase atmospheric CO2 for at least a century because new carbon debt continuously exceeds NPP. Assuming biofuels are carbon neutral may worsen irreversible impacts of climate change before benefits accrue. Instead, explicit dynamic models should be used to assess the climate impacts of biofuels.").	Rejected. The mitigation potential of bioenergy is reviewed in 7.4.4, including the mitigation value of different bioenergy systems and the influence of the methods used in quantification.	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America
80839	75	46	76	5	Biomass substitution for fossil fuels is not an effective mitigation strategy because burning forest biomass for power generation emits more CO2 per unit of final energy than burning fossil fuels. Mary S. Booth, Not carbon neutral: Assessing the net emissions impact of residues burned for bioenergy, Environ. Res. Lett. 13 (21 February 2018); Sterman J. D., et al. (2018) Does replacing coal with wood lower CO2 emissions? Dynamic lifecycle analysis of wood bioenergy, Envtl. Research Letters 13(015007):1–10, 1 ("We simulate substitution of wood for coal in power generation, estimating the parameters governing NPP and other fluxes using data for forests in the eastern US and using published estimates for supply chain emissions. Because combustion and processing efficiencies for wood are less than coal, the immediate impact of substituting wood for coal is an increase in atmospheric CO2 relative to coal. The payback time for this carbon debt ranges from 44–104 years after clear-cut, depending on forest type—assuming the land remains forest. Surprisingly, replanting hardwood forests with fast-growing pine plantations raises the CO2 impact of wood because the equilibrium carbon density of plantations is lower than natural forests. Further, projected growth in wood harvest for bioenergy would increase atmospheric CO2 for at least a century because new carbon debt continuously exceeds NPP. Assuming biofuels are carbon neutral may worsen irreversible impacts of climate change before benefits accrue. Instead, explicit dynamic models should be used to assess the climate impacts of biofuels.").	Rejected. The mitigation potential of bioenergy is reviewed in 7.4.4, including the mitigation value of different bioenergy systems and the influence of the methods used in quantification.	Gabrielle Dreyfus	Institute for Governance & Sustainable Development	United States of America
58027	76	1	76	10	There is little attention paid to the importance of the forest aging process and how that process figures into anticipated sequestration rates. Suggest that aging is also a risk worth considering, as it certainly impacts vulnerability to disturbance.	Accepted. Declining rate of sequestration as forests mature is now mentioned.	Government of United State	U.S. Department of State	United States of America
81723	76	5	76	10	Should note that "integrated landscape approaches that aim to create a mosaic of land uses, including conservation, agriculture, forestry and settlements" is an ideal that is difficult for forestry plantation processing - where logs are harvested, transported to processors or ports, and then to secondary processors. For this scale is really important. Collecting logs from small integrated lots across the breadth of a country is costly. It would be better to refer to this here as 'clusters' within the landscape where large scale forestry can take place next door to wood processors and - say - biorefineries - or even industries that use process heat. This way energy efficiencies are maximised, and the cost of wood and wood products are reduced and easy for switching to occur. Right tree, right place and right scale' is very important. Also suggest ensure figures in this chapter are readable. Useful comment - reference? Go back to MPI for reference and note that this is a global issue although reference may be NZ-specific	Partly accepted. The comment is hard to follow, especially the final points. We agree that mosaic approaches, while more sustainable, could increase costs and reduce efficiencies for large scale mechanised agriculture and forestry. We have added mention that the socioeconomic objectives and context should be considered.	Government of New Zealand	Ministry for the Environment	New Zealand
1475	76	8	76	8	Add Kongsager 2018 to the cited references " (Freeman et al. 2015; Kongsager 2018; Nielsen 2016;" • Kongsager, R. (2018). Linking Climate Change Adaptation and Mitigation: A Review with Evidence from the Land-Use Sectors. Journal: Land (7)4, 158. https://doi.org/10.3390/land7040159	Rejected. The proposed paper adds no additional information	RICO KONGSAGER	University College Copenhagen	Denmark
22259	76	11	76	12	it seems that there is the same argument with the same reference p.80	Accepted. The repeated text has been deleted.	Government of France	Ministère de la Transition écologique et solidaire	France

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61443	76	19	77	29	I would like to commend the authors for producing a well-written chapter bringing together the cross-sectoral perspectives and pulling together findings from other chapters in the report. I would especially like to acknowledge the relevance of Box 12.1 as an entry point for developing policies within the UNCCD. This is highly relevant to UNCCD and I appreciate that the land degradation neutrality framework has been included in this section.	Noted, thanks.	Graham von Maltitz	UNIVERSITY OF STELLENBOSCH; UNCCD SCIENCE POLICY INTERFACE	South Africa
58029	77	2	77	2	The authors indicate that farmer-managed natural regeneration is low cost, but it is not clear in what situations it will be low cost and to what low cost is relative.	Accepted. Clarified that it is low cost relative to other restoration approaches; additional reference added, that addresses constraints to FMNR.	Government of United State	U.S. Department of State	United States of America
58031	77	19	77	21	The authors indicate that, with the LDN approach, it is important that land condition be maintained, but isn't it also valuable to have land condition be temporarily improved even if it is not maintained over time? If it is lower cost or infeasible to permanently improve land condition, temporary improvements in particular areas that may change over time would also provide significant benefits.	Rejected. In order to achieve "no net loss of healthy and productive land", and to maximise climate and socioeconomic benefits from interventions in sustainable land management and land restoration/rehabiltiation, the aim should be to maintain improvemernts in land condition in the long term.	Government of United State	U.S. Department of State	United States of America
58033	77	25	77	29	In this paragraph, the authors discuss the emphasis on multifunctional landscapes, but there is no discussion of the type of situation in which this would be optimal. In some countries or regions, multifunctional landscapes may be infeasible.	Rejected. Expansion to provide further detail not possible due to word limit. We assert that multifuncitonal landscapes are applicable in all contexts, although the mix of land uses and mitigaiton options will differ depending on environmental and socioeconomic characteristics.	Government of United State	U.S. Department of State	United States of America
58035	78	1	78	5	Box 12.1 Figure 1 excludes human development, market systems, agriculture, and livestock. The initial figure with three interactions imposes preferences on people by restricting the world to only three potential outcomes that must be integrated together, giving equal weight to each. This figure could be deleted.	Rejected. The figure illustrates the holistic approach to management of land degradation that is promoted through the land degradation neutrality target of Sustainable Developement Goal 15. The cited literature on LDN discusses all the elements raised in this comment.	Government of United State	U.S. Department of State	United States of America
117	78	6	90	2	The section on Food security is far too brief and, moreover, seems a chaotic bin of left-overs. AR5 had over 90 pages on this topic, and was to-the-point.	Accepted. Food security section has been deleted, as we do not have space to expand here. Food security is now mentioned briefly as one of the impacts of land-based mitigation and discused in detail in chapter XXX. 17?	Harry Aiking	Vrije Universiteit, Institute for Environmental Studies	Netherlands
58037	78	7	79	16	This section should consider additional references that support this concept: ""It is not about land being 'available' or 'marginal.' Rather, it is about improving land management for multiple services, everywhere. One of the first opportunities is to improve biomass productivity and utility on the 400-500 million hectares of lands that burn every year. This issue should be discussed as an opportunity. Andela et al. (2019) state that ""Worldwide, fires burn an area about the size of the European Union every year (423 Mha yr-1; Giglio et al., 2018). The majority of burned area occurs in grasslands and savannas where fires maintain open landscapes by reducing shrub and tree cover (Scholes and Archer, 1997; Abreu et al., 2017). However, all major biomes burn. Climate controls global patterns of fire activity by driving vegetation productivity and fuel buildup as well as fuel moisture (Bowman et al., 2009). Humans are the dominant source of ignition in most flammable ecosystems."" Reference (others provided previously): Andela, N., Morton, D. C., Giglio, L., Paugam, R., Chen, Y., Hantson, S., van der Werf, G. R., and Randerson, J. T.: The Global Fire Atlas of individual fire size, duration, speed and direction, Earth Syst. Sci. Data, 11, 529-552, https://doi.org/10.5194/essd-11-529-2019, 2019.	Accepted. Extracting biomass for bioenergy as a wildfire management strategy added in table 12.6	Government of United State	U.S. Department of State	United States of America
58039	79	4	79	7	It is not clear where the abandoned and degraded land is located and this will affect the cost of transportation of food from where it is produced to population centers. The suggestion that abandoned or degraded land is a good opportunity to grow energy crops is not necessarily valid. This land may not be useable for energy crop growth depending on soil health and water availability. Growing crops on marginal land may require additional inputs such as fertilizer which could increase GHG emissions when cultivating crops on marginal or abandoned land.	Noted. These constraints are already mentioned and we cannot expand further due to space constraints.	Government of United State	U.S. Department of State	United States of America
22261	79	8	79	8	Concerning the term "marginal land" perhaps repeat here the report's definition of "marginal land" and "abandoned agricultural land"... Those definitions are not universal. E.g.: Elbersen B, van Eupen M, Verzandvoort S, et al (2020) Deliverable 2.6 Methodological approaches to identify and map marginal land suitable for industrial crops in Europe Gerwin W, Repmann F, Galatsidas S, et al (2018) Assessment and quantification of marginal lands for biomass production in Europe using soil-quality indicators. Soil 4:267–290. https://doi.org/10.5194/soil-4-267-2018 Kang S, Post WM, Nichols JA, et al (2013) Marginal Lands: Concept, Assessment and Management. J Agric Sci 5:129–139. https://doi.org/10.5539/jas.v5n5p129 Lewis SM, Kelly M (2014) Mapping the potential for biofuel production on marginal lands: Differences in definitions, data and models across scales. ISPRS Int J Geo-Information 3:430–459. https://doi.org/10.3390/ijgi3020430	Partly accepted. We have stated that the definition is contested, and added two of the proposed references.	Government of France	Ministère de la Transition écologique et solidaire	France
10035	79	12		14	Reference is made to the statement says: 'The highest increases in the population at risk of hunger are expected to occur in Sub-Sahara Africa and Asia '. Suggestion. A reference or data to support the statement need to be included.	Accepted. Reference added (Hasegawa et al., 2018)	Government of Indonesia	Ministry of Environment and Forestry	Indonesia

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46237	79	33	79	36	It is suggested to consider the following information derived from IPBES (2016) at the end of this para: "More than three quarters of the leading types of global food crops rely to some extent on animal pollination for yield and/or quality. Pollinator-dependent crops contribute to 35 per cent of global crop production volume" (Page 8). In a next step you may wish to consider the following information: "Moving towards more sustainable agriculture and reversing the simplification of agricultural landscapes offer key strategic responses to risks associated with pollinator decline [.....] These strategies can concurrently mitigate the impacts of land-use change, land management intensity, pesticide use and climate change on pollinators" (page 10). Source: IPBES (2016): Summary for policymakers of the assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on pollinators, pollination and food production. S.G. Potts, V. L. Imperatriz-Fonseca, H. T. Ngo, J. C. Biesmeijer, T. D. Breeze, L. V. Dicks, L. A. Garibaldi, R. Hill, J. Settele, A. J. Vanbergen, M. A. Aizen, S. A. Cunningham, C. Eardley, B. M. Freitas, N. Gallai, P. G. Kevan, A. Kovács-Hostyánszki, P. K. Kwapong, J. Li, X. Li, D. J. Martins, G. Nates-Parra, J. S. Pettis, R. Rader, and B. F. Viana (eds.). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany. 36 pages.	Noted. The potential for biomass crops to enhance landscape diversity and support pollinators is mentioned.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
58041	79	39	79	39	"can by" should be "can be"	Accepted. The section has been restructred and this text merged with other sections. This sentence has been corrected.	Government of United State	U.S. Department of State	United States of America
3941	80	1		3	This statement must be tuned: instead of "can supply", should be "might supply"; since it is strongly soil and climate specific, with no effects in most soils.	Partly accepted . "Can" substituted with "could".	Rosa M Poch	ITPS and UdL	Spain
12107	80	1	80	3	Suggest adding that the technique could potentially be part of the solution to problems of nutrient limitation in forests (de Oliveira Garcia, 2020) as well as crops. DE OLIVEIRA GARCIA, W. A., T.: HARTMANN, J.: KARSTENS, K.: POPP, A.: BOYSEN, L. R.: SMITH, P.: GOLL, D. 2020. Impacts of enhanced weathering on biomass production for negative emission technologies and soil hydrology. Biogeosciences, 17, 2107-2133.	Accepted, mention of benefit to forest productivity from enhanced weathering, and citation, have been added.	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
58043	80	4	80	16	The discussion of wind and solar is redundant to the discussion in Section 12.5.2.1.	Noted. The section has been restructured and this text merged with other sections. The repeated text has been deleted.	Government of United State	U.S. Department of State	United States of America
22263	80	7	80	9	It seems that there is the same argument with the same reference p.76	Noted. The section has been restructured and this text merged with other sections. The repeated text has been deleted.	Government of France	Ministère de la Transition écologique et solidaire	France
22265	80	9	80	10	We suggest to rephrase the sentence "Global mapping of solar panel efficiency showed that croplands 10 having the greatest median solar potential (Adeh et al. 2019)." as its meaning seems unclear	Accepted. Sentence reworded: Global mapping of solar panel efficiency showed that croplands, grasslands and wetlands haveare located in regions with the greatest solar PV potential	Government of France	Ministère de la Transition écologique et solidaire	France
58045	80	17	82	1	Table 12.11 does not summarize previous information. It introduces information not previously discussed such as improved grazing and does not summarize well the information in the text, e.g., solar generated electricity. Consider removing Table 12.11.	Taken into account. The table was revised and cross-references to sections added	Government of United State	U.S. Department of State	United States of America
52579	80	19			Such impacts on the land should be included in the SPM	Noted; the potential to include the land-footprint of other mitigation options in the SPM will be discussed amongst the SPM drafting authors and subject to further government review comments on the SPM.	Government of Saudi Arabia	Sustainability Advisor to the Minister Ministry of Petroleum and Mineral Resources	Saudi Arabia
58047	80	19	81	1	It would be helpful to see better integration of forest management and reduced deforestation and degradation. These are inherently linked.	Noted. Forest conservation and improved forest management - including both benefits and risks - are covered in Ch7. This section covers risks and opportunities assocaited with mitigation options that change land use (noting also response to #57951)	Government of United State	U.S. Department of State	United States of America
77651	80		82		Improved protection and conservation management of primary and other natural forests should be added to this table. Estimates of total ecosystem carbon stocks in primary tropical forests range from 141-159 pg C or 49-53% of tropical forest carbon. Avoiding emissions from deforestation and degradation of primary forests is the highest priority mitigation strategy, supporting a stable carbon reservoir and providing a low risk carbon sink. (Understanding the importance of primary tropical forests as a mitigation strategy, Mackey et al, Mitigation and Adaptation Strategies for Global Change, 2020) Benefits include improved climate resilience; secure provision of ecosystem services; maintenance of cultural and livelihood benefits for indigenous communities; reduced threat of fire and reduced fire severity; enhanced adaptive capacity; and reduced risk of premature release of GHG to the atmosphere. Resistance of primary forests to fire is well illustrated in the Kayapo case study on page 32 of The Nexus Report: Nature Based Solutions to the Biodiversity and Climate Crises, Barber C.V, Petersen R., Young V, Mackey B, Kormos C, 2020 Given that logging primary forests reduces carbon storage by on average 30- 50%, it is strange to include wood products as a benefit from ending deforestation and forest degradation. (Understanding the importance of primary tropical forests as a mitigation strategy, Mackey et al, Mitigation and Adaptation Strategies for Global Change, 2020)	Noted. Forest conservation and improved forest management - including both benefits and risks - are covered in Ch7. This section covers risks and opportunities associaed with mitigation options that change land use (noting also response to #57951)	Virginia Young	Australian Rainforest Conservation Society	Australia
3943	81				Improved cropland management (increasing soil carbon stock) should be Improved cropland management (increasing soil organic carbon stock)	Noted. The reviewer is correct, however this additional detail is not required; wording is consistent with the term used throuought the chapter.	Rosa M Poch	ITPS and UdL	Spain
22267	81		81		Table 12.11, last row of the page 81 : What is the reason for considering "Management of organic waste (food waste....MSW) solely under this sub-section (Options that don't occupy land used for food production) although the management of such organic waste is already widely practiced on land used for food production?	Noted. this mitigation option is placed in this category because the produciton of feedstock does not occupy land used for food production. Text added to explain this.	Government of France	Ministère de la Transition écologique et solidaire	France

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
22269	81		81		Table 12.11 : beofre to last row on the page, concerning "Risk of methane slip", it can be mentioned here the same risks cited just below = for "Management of organic waste....MSW)" = "Can contain contaminants (heavy metals, organics, pathogens)", because these risks exist with manure management too.	Accepted, text added	Government of France	Ministère de la Transition écologique et solidaire	France
22271	81		81		Table 12.11, last row, concerning the statement "return of nutrients to farmland." on the last column, it may be added to "....return of nutrients to farmland" "depending on process and spreading techniques", because nitrogen in the NH4 form (major form of N in digestate) is particularly sensitive to loss by volatilization when not properly spread.	Accepted. Clarification of the need for care to minimise volatilisation is now added in the main text par on anaerobic digestion.	Government of France	Ministère de la Transition écologique et solidaire	France
22273	81		81		Table 12.11, last row, concerning the term "pyrolisis" on the last column, depending on the raw material and process used, there might be substantial nitrogen losses during pyrolysis so that making a direct linkage between pyrolysis and "return of nutrients to farmland" seems adequate for some nutrients (for P, and micro-nutrients for example) but partly true for nitrogen.	Accepted. Clarification that large fraction of the N is lost during pyrolysis now added in the main text par on pyrolysis.	Government of France	Ministère de la Transition écologique et solidaire	France
86807	82	3			Bioeconomy,and the circular economy are only some of the available tools to mitigate and adapt to climate change, and to achieve sustainable food production systems. Thus, and although we appreciate the examples provided in the Cross-Working Group Box 3, it is not clear if the aim is to promote them as an end in themselves. We believe it should be clarified that those tools are options available to countries who wish to use them, but not a goal all should pursue. In addition, we suggest replacing "climate-smart agriculture" by "sustainable agriculture", being this term the one agreed multilaterally in the 2030 Agenda and its SDGs (in particular SDG 2).	Taken into account. Removed the boxes on climate-smart agriculture and climate-smart forestry and instead summarized these in a paragraph. Climate-smart agriculture remains in the text with reference to IPCC-SRCCL. The text was revised with the aim to make the message clear that tools are options available to countries who wish to use them, but not a goal all should pursue	Government of Argentina	Ministry of Environment and Sustainable development of Argentina	Argentina
37419	82		90		Delete cross-box. Bioeconomy is a term of art and not a scientific expression. It represents a particular aspect of EU policy. The standard term is environmental economics, natural resource economics or related expressions that capture the fact that economies depend on natural resources and also equally depend on industrial processes. The use of term bioeconomy in IPCC therefore is an attempt to enforce views of particular parties to the UNFCCC. Bioeconomy unlike the term sustainable development for example has not been agreed upon via a multilateral process.	Taken into account. While this x-WG box is not deleted it has been shortened and revised thoroughly. We have taken care to make the message clear that mitigation and adaptation through bioeconomy solutions are available to countries who wish to use them, but bioeconomy solutions are means for achieving mitigation and adaptation and not goals that all should pursue. The concept bioeconomy is considered to be well established worldwide. As an example, Dietz et al (2018) provide an overview of 41 countries worldwide (Europe, N&S America, Africa, Oceania, and Asia that pursue explicit political strategies to expand and promote their bioeconomies. (https://doi.org/10.3390/su10093190).	Government of India	Ministry of Environment, Forests and Climate Change	India
58049	83	1	83	2	Refer readers to Box 12.2 on page 94 for a discussion of "circular economy".	Accepted. Cross-reference to Box 12.2 has been inserted	Government of United State	U.S. Department of State	United States of
58051	83	1	87	1	Discussions of climate-smart forestry and agriculture are good but seem incomplete in that integrated agro-silva-pastoral-urban systems can reap even greater benefits with smaller footprints.	Taken into account. The boxes on climate-smart agriculture and climate-smart forestry have been removed and the concepts are summarized in one paragraph. Integrated solutions are covered extensively	Government of United State	U.S. Department of State	United States of America
58053	83	10	83	10	"Planetary boundaries" is too vague. Give some examples.	Taken into account. Text referring to planetary boundaries has been deleted	Government of United State	U.S. Department of State	United States of America
27853	84	2	84	4	Delete "so that fossil carbon remains underground (Tong et al. 2019; Peters et al. 2020). It is not possible to maintain current systems and trends in consumption patterns, while just replacing fossil carbon with biogenic carbon."	Taken into account. The commented sentences have been deleted	Eleni Kaditi	Organization of the Petroleum Exporting Countries, OPEC	Austria
61875	84	6	84	8	"Energy efficiency and conservation measures are essential, together with technologies and systems that do not rely on carbon-based energy and materials, not the least renewable electricity supporting, inter alia, electrification of transport as well as industry processes and residential heating." Why specifically emphasize "renewable electricity" over the more technology neutral and scientifically precise "low-carbon electricity"? Further, nuclear energy can contribute significantly to clean district heating of buildings (Chen et al., 2021,https://doi.org/10.1016/j.energy.2020.119546; Lindroos et al, 2019, https://doi.org/10.1080/15567249.2019.1595223; Värri et al, 2019, https://doi.org/10.3390/en12112195 and Teräsvirta et al, 2020, https://doi.org/10.3390/en13153782). Rephrase accordingly.	Accepted. reference to "Renewable electricity" was deleted	Rauli Partanen	Think Atom	Finland
65915	84	6	84	8	"Energy efficiency and conservation measures are essential, together with technologies and systems that do not rely on carbon-based energy and materials, not the least renewable electricity supporting, inter alia, electrification of transport as well as industry processes and residential heating." Also nuclear supports trivially electrification of transport, industry processes, and also clean district heating (Chen et al., 2021, https://doi.org/10.1016/j.energy.2020.119546). If renewables are emphasized in this context, so should be nuclear. Rephrase accordingly	Accepted. reference to "Renewable electricity" was deleted	Eero Hirvijoki	Aalto University	Finland
58055	84	19	84	34	Use consistent units for land area (both Mkm2 and Mha are used here).	Accepted. Text revised	Government of United State	U.S. Department of State	United States of America
58057	84	37	84	37	The sentence reads 'avoiding reforestation'. Do the authors mean 'avoided deforestation'?	Taken into account. Yes, we referred to avoided deforestation. This text was however deleted in the SOD revision	Government of United State	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
10037	85	1			The quality of 'Cross-Working Group Box 3, Figure 2. --- Source: IPCC (2019)' can be improved.	Taken into account. The figure was a placeholder, borrowed from SRCCL SPM. It was deleted in the revision	Government of Indonesia	Ministry of Environment and Forestry	Indonesia
29707	85	4	88	7	Generally, there is much overlap between chapter 12 and chapter 7. Particularly in cross-working group box 3, about bioeconomy, pages 85-88 is mostly about integrated solutions in agriculture that could respond to various challenges simultaneously. These integrated perspectives are much appreciated. However, some of these perspectives also naturally belong in chapter 12.4 about food systems, as well as in chapter 7. Probably, it should be stated clearer that much of chapter 7 and 12.4 can only take a partial perspective responding to individual challenges, while agriculture is by nature an integrated system. Therefore such integrated solutions deserve more attention for instance in 12.4, and it may also be mentioned that much remains to be done to identify and assess integrated solutions and integrate them into policy.	Accepted. We reduced text on agroecology and also coordinated with authors revising Ch7 section 12.4. Text on integrated land use systems in section 7.4.4 was reduced and instead include cross-ref to this x-WG box	Government of Norway	Norwegian Environment Agency	Norway
58059	85	8	85	12	Add citations for this statement.	Taken into account. The statement was deleted from this section since it repeated text in background section, which is supported with references	Government of United State	U.S. Department of State	United States of America
73921	85	8			Please distinguish which source it is from the ones by 'Smith et al.' in 2019.	Accepted. This has been clarified. FYI the reference is Smith, P., et al., 2019b: Impacts of Land-Based Greenhouse Gas Removal Options on Ecosystem Services and the United Nations Sustainable Development Goals. Annu. Rev. Environ. Resour., 44, 1–32, https://doi.org/10.1146/annurev-environ-101718-033129.	Raehyun KIM	National Institute of Forest Science	Republic of Korea
14845	85	21	85	25	Approaches like Backcasting can also support the analysis of onflicts and synergies between environmental policy goals. See e.g., van der Voorn, T., Svenfelt, Å., Björnberg, K.E. et al. Envisioning carbon-free land use futures for Sweden: a scenario study on conflicts and synergies between environmental policy goals. Reg Environ Change 20, 35 (2020). https://doi.org/10.1007/s10113-020-01618-5	Noted. Thank you for informing about the publication. We did not cite it here since we judged that the studies already cited provide support for the statement made in this sentence.	Tom van der Voorn	Institute of Environmental Systems Research	Netherlands
1473	85	24	85	24	Add Kongsager 2018 to the cited references "D'Annolfo et al. 2017; Kongsager 2018; Momblanch et al. 2019" • Kongsager, R. (2018). Linking Climate Change Adaptation and Mitigation: A Review with Evidence from the Land-Use Sectors. Journal: Land (7)4, 158. https://doi.org/10.3390/land7040158	Accepted. The revised text acknowledges that analyses of synergies and trade-offs between adaptation and mitigation in the agriculture and forestry sectors show that activities and outcomes depend on context, design and implementation, so actions have to be tailored to the specific conditions to minimize trade-offs. Kongsager 2018 was cited	RICO KONGSAGER	University College Copenhagen	Denmark
70019	86	8	86	14	In parenthesis, add the following reference: "Cordova et al. 2019"	Taken into account. The reference Cordova et al. 2019 was identified via correspondence with reviewer (see below). The study was considered complementary to other studies already cited and was therefore included. Córdova, R., Hogarth, N., Kanninen, M. 2019. Mountain farming systems' exposure and sensitivity to climate change and variability: Agroforestry and conventional agriculture systems compared in Ecuador's indigenous territory of Kayambi people. Sustainability 11(9) 2623. DOI: https://doi.org/10.3390/su11092623	Markku Kanninen	University of Helsinki	Finland
58061	86	31	86	31	Along with a "lack of support, policies, and incentives" an adequate regulatory framework is lacking while there is a surfeit of perverse incentives.	Taken into account. These aspects are addressed in section "Governing the solution space"	Government of United State	U.S. Department of State	United States of America
22275	87	1	87	8	it is true that LCA would estimate higher impacts per t of produce issued from organic/agroecological systems than from conventional ones (due to lower inputs), yet it may also estimate lower impacts per ha of cropland. Both functional units are complementary and useful in comparative agricultural LCAs. E.g. Salou T, Le Mouël C, van der Werf HMG (2016) Environmental impacts of dairy system intensification: the functional unit matters! J Clean Prod 1–10. https://doi.org/10.1016/j.jclepro.2016.05.019 Avadí A, Nitschelm L, Corson M, Vertès F (2016) Data strategy for environmental assessment of agricultural regions via LCA: case study of a French catchment. Int J Life Cycle Assess 21:476–491. https://doi.org/10.1007/s11367-016-1036-6	Noted. The commented sentence about impact assessment methodology was deleted in the revision	Government of France	Ministère de la Transition écologique et solidaire	France
73923	87	30			The work 'FAO, 2020b' cannot be found in the References.	Noted	Raehyun KIM	National Institute of Forest Science	Republic of Korea

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
73925	87	33			The work 'Ockleford et al. 2017' cannot be found in the References.	Taken into account. This box was deleted (Clarification: The SOD version of the WG3 box cites Ockleford et al. 2017 instead of EFSA, 2017)	Raehyun KIM	National Institute of Forest Science	Republic of Korea
58063	88	9	90	2	This section "Governing the Solution Space" is written quite differently and is a break in flow from the previous pages in Cross Working Group Box 3. The discussion of prioritization of land use lacks any economic consideration and is too prescriptive. Figure 4 is a good example with its statement of "Use resources for food first" near the top of the figure. At minimum, Figure 4 should be replaced with another example. A better fix would be to delete the entire "Governing the Solution Space" section and use that space to more clearly define other terms (e.g., planetary boundaries, climate-smart agriculture) used in Cross Working Group Box 3.	Taken into account Figure BIOECO.4 and associated text has been deleted. The section Governing the solutions space has been shortened and revised to sharpen messages. The term planetary boundaries is not used in the revised version. Other terms, such as climate smart agriculture and circular economy, is elaborated and/or associated with citations of additional literature providing more extensive information	Government of United State	U.S. Department of State	United States of America
58065	88	10	88	42	Discussion of the solution space could be sharpened. Yes, the planet has a defined land area, but there's no need to keep repeating that because what is important is that nearly all of the planets land is poorly managed due to the wrong incentives, focused on short term profits and windfall harvests, and distorted by the many subsidies and lack of consideration of externalities as costs, and the longer term needs and benefits of climate smart management.	Noted. This box was shortened and subject to significant revision based on review comments, with the aim to sharpen messages on options for improving land and biomass use, and governance measures to promote such options and address unsustainable land uses	Government of United State	U.S. Department of State	United States of America
27855	88	15	88	21	Delete "Nonetheless, there is broad agreement that taking the needs and perspectives of multiple stakeholders into account in a transparent process during negotiations improves the chances of achieving outcomes that maximise synergies while limiting trade offs. Yet differences in agency and power between stakeholders or anticipated changes in access to or control of resources can undermine negotiation results even if there is a common understanding of the overarching benefits of more integrated environmental agreements and the need for greater coordination and cooperation to avoid longer-term losses to all."	Rejected. The reviewer did not provide any motivation for the proposed deletion of text and the author team consider the text to be relevant for the context in this box	Eleni Kaditi	Organization of the Petroleum Exporting Countries, OPEC	Austria
119	89	1	89	1	Box 3, Fig. 4 contains "3. Use livestock to valorise biomass", which is at odds with FAO 2006 (Steinfeld et al.) Livestock's Long Shadow. Please elaborate.	Noted. The Figure was deleted	Harry Aiking	Vrije Universiteit, Institute for Environmental Studies	Netherlands
10821	90	3	90	7	All along this presentation of cross-sectoral issues, one wonders why integrating tools such as IAM are not used to help clarify cross-sectoral interactions. Maybe this point is raised in some of the references in 12.6 (I was unable to look through all of them); still this would deserve a discussion. And if existing integrating models are not adequate for exploring and quantifying cross-sectoral effects, is there no effort reported in the literature for developing more adequate modeling tools?	Rejected: IAMs are considered elsewhere in the report. This section focuses on cross-sectoral effects of individual mitiation actions and so provides a different perspective	Philippe Waldteufel	CNRS	France
70615	90	20	90	20	please mention which chapters	Accepted: Reference to Chapter 16 added	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
84583	90	24	90	24	Please consider to include figure 1 from "Karlsson, M., Alfredsson E. & Westling N. (2020) Climate policy co-benefits: a review, Climate Policy 20, 292-316. DOI: 10.1080/14693062.2020.1724070".	Rejected: Space limitations preclude this figure from being included. However the paper has been referred to in this section	Mikael Karlsson	KTH Royal Institute of Technology	Sweden
19901	90	31	90	31	Please add: "Recently the term 'implications' has been proposed in regards to the uncertain, yet anticipated potential effects (positive and negative) of future CDR applications – identified through a broad-based transdisciplinary mapping (Honegger et al., 2021)." Reason: There is an emerging need to anticipate potential implications of CDR. New reference: Honegger, M., Michaelowa, A., and Pan, J. (2021, under review). Potential implications of Solar Radiation Modification for achievement of the Sustainable Development Goals", Mitigation and Adaptation Strategies to Global Change.	Rejected: This section is a very broad section rather than focusing on CDR. Also the term seems to be proposed in just one paper and isnt considered to add substantially to the narrative	Axel Michaelowa	University of Zurich	Switzerland
70617	90	36	90	36	there is a problem with the association of"robust" or "high" evidence with "low agreement", since those who agree or disagree are part of the scientific community, how can they deny or overlook robust evidence?	Rejected. There is a lot of discussion in the literature on this topic hence robust evidence, but little agreement	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
85863	91	8	91	11	Suggest rephrase this statement to more accurately reflect the literature. It is a stretch to characterise lithium batteries as 'creating major water and waste challenges' in Australia. The literature cited does not support this finding, which is also inconsistent with the statement in Chapter 10, page 99. '.... sustainability challenges are emerging.'	Accepted: Wording changed to be more neutral. "has the potential for creating water and waste challenges if not managed properly"	Government of Australia	Department of Industry, Science, Energy and Resources	Australia
20163	91	20	91	23	Also: Nikas A., Gambhir A., Trutnevyte E., Koasidis K., Lund H., Thellufsen J.Z., Mayer D., Zachmann G., Miguel L.J., Ferreras-Alonso N., Sognnaes I., Peters G.P., Colombo E., Howells M., Hawkes A., van den Broek M., Van de Ven D.J., Gonzalez-Eguino M., Flamos A., & Doukas H. (2021). Perspective of comprehensive and comprehensible multi-model energy and climate science in Europe. Energy, 215, 119153. And: Van Soest, H. L., Van Vuuren, D. P., Hilaire, J., Minx, J. C., Harmsen, M. J., Krey, V., ... & Luderer, G. (2019). Analysing interactions among sustainable development goals with integrated assessment models. Global Transitions, 1, 210-225.	Accepted: Included the van Soest et al article, but not the Nikas article as that is not considered to be relevant.	Nikas Alexandros	National Technical University of Athens	Greece

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
77653	91	20	91	21	Given that the biodiversity crisis is as serious for life on earth as the climate crisis with profound implications for the SDG's, analysis of the linkages (positive and negative) of potential climate mitigation action (particularly in the AFOLU sector) should be included. There is little room to manoeuvre and no room for large scale 'mistakes'. This analysis should be informed by the post 2020 goals of the CBD. Perhaps a special report is required on the Nexus between climate and biodiversity that looks at the inter-linkages between the two crises, brings together key biodiversity and ecosystem adaptation experts and sheds more light on the functional role of biodiversity in ensuring ecosystem integrity and stability and implications of its loss for stable long term carbon storage. Either an IPCC special report or joint IPBES/IPCC report would be appropriate. These existential crises amplify each other so avoiding trade offs and achieving synergies is imperative, yet there is little sense of the urgency called for by IPBES in 2019 let alone the 2005 Millenium Ecosystem Assessment that warned that if we did not change course before 2020 our options for doing so would be severely diminished. The two way flows between these two crises are not explicitly recognised in this chapter or chapter 7 and from a mitigation perspective it's crucial to understand the risks for effective climate mitigation if we don't work to protect our most stable and resilient carbon stocks. Primary carbon dense ecosystems are irreplaceable in relevant time frames; and older natural forests offer more chance and lower risk of robust long-term sequestration than planting new trees or bioenergy tree crops. (Understanding the importance of primary tropical forests as a mitigation strategy, Mackey et al, Mitigation and Adaptation Strategies for Global Change, 2020; IUCN Policy on Primary Forests including Intact Forest Landscapes; The Nexus Report: Nature Based Solutions to the Biodiversity and Climate Crises, Barber C.V, Petersen R., Young V, Mackey B, Kormos C, 2020; The Economics of Biodiversity, the Dasgupta Review, 2021)	Rejected: It is suggested that this comment is more relevant to Chapter 7 rather than this cross-sectoral chapter, and should be referred to that chapter	Virginia Young	Australian Rainforest Conservation Society	Australia
22305	91		92		SR1.5 reported much detailed risks and impact, for instance concerning land use, which might be included in this table TS.6, citing SRCCL, SPM B3.4.: "For projected socioeconomic pathways with low population, effective land-use regulation, food produced in low-GHG emission systems and lower food loss and waste (SSP1), the transition from low to moderate risk to food security, land degradation and water scarcity in dry lands occur between 1 and 4 million km2 of bioenergy or BECCS (medium confidence). By contrast, in pathways with high population, low income and slow rates of technological change (SSP3), the transition from low to moderate risk occurs between 0.1 and 1 million km2 (medium confidence)." {6.4; Cross-Chapter Box 7 in Chapter 6; Table SM7.6; Box SPM1}	Rejected: It is not clear what the reviewer would like to see here. This comment would be better placed in more specific sections of the report, rather than in this cross-sectoral section	Government of France	Ministère de la Transition écologique et solidaire	France
58067	92	1	92	9	Figure 12.11 is hard to read and interpret. The authors should either remove it or describe it in more detail.	Rejected: This is the only comment that calls for removal of this figure. The figure has been completely redrawn, in line with comment 22277, which is thought to improve readibility	Government of United State	U.S. Department of State	United States of America
61877	92	1	92	9	In Figure 12.11 the box "E. Renewable energy" should instead be "E.Low-carbon energy" or have "Renewable and nuclear energy". Indeed, the benefits of nuclear energy towards all the SDGs are substantial, as can be found in pages 21-26 in UNECE 2021, https://unece.org/sustainable-energy/publications/nuclear-entry-pathways and in IAEA https://www.iaea.org/sites/default/files/bull573sept2016.pdf. Please revise accordingly.	Accepted. Figure updated. See also next comment 65917	Rauli Partanen	Think Atom	Finland
65917	92	1	92	9	In Figure 12.11 the box "E. Renewable energy" should instead be "E. Low-carbon energy". After all, also nuclear energy contributes towards the SDGs, such as "clean energy" and "reduced air pollution". A more detailed account of nuclear energy and the SDGs you can find from my comments for Chapter 17. As a bare minimum, you should consult the IAEA stance available at https://www.iaea.org/bulletin/57-3 and the United Nations Economic Commission for Europe (UNECE) study https://unece.org/sustainable-energy/publications/nuclear-entry-pathways which demonstrates nuclear to support every single one of the SDGs.	Accepted. Change made to figure to include low carbon energy rather than renewable.	Eero Hirvijoki	Aalto University	Finland
65921	92	17	93	12	The paragraph literally mentions every low-carbon technology in a favourable light except nuclear energy. There should be examples of the cross-sectorial benefits of nuclear energy in, e.g., displacig carbon-intensive electricity production, producing process heat, in hydrogen production, providing desalination, clean district heat, etc. Literature is full of studies in all these areas. Revise the paragraph accordingly. I find this systematic dismissal of nuclear energy throughout the entire report rather odd.	Accepted: Applications of nuclear added.	Eero Hirvijoki	Aalto University	Finland
65919	92	19	92	20	The credibility of the reference (Jacobson et al., 2017, https://doi.org/10.1016/j.joule.2017.07.005) is highly questionable. The cited reference expands along a line of work that has been comprehensively rebutted (Clack et al., https://doi.org/10.1073/pnas.1610381114). The IPCC should resort only to non-disputed research.	Accepted. Reference has been removed	Eero Hirvijoki	Aalto University	Finland
5551	92	20	92	20	replace Renewables" by "low carbon sources"	Accepted: Change made	Michel SIMON	Retraité/ Pdt d'association	France
24703	92	20	92	20	Hydrogen produced via electrolysis: both renewable and nuclear power can be used in this process (see reference already used in the chapter: Bicer, Y., and Dincer, I. (2017). Life cycle assessment of nuclear-based hydrogen and ammonia production options: A comparative evaluation. International Journal of Hydrogen Energy, 42(33), 21559–21570. https://doi.org/https://doi.org/10.1016/j.ijhydene.2017.02.002). So we recommend replacing "Hydrogen and fuel cells, coupled with renewable energy" with "Hydrogen and fuel cells, coupled with low-carbon energy"	Accepted: Change made	Ann Jessica Johnson	FORATOM (European Atomic Forum)	Belgium

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
22277	92		92		Figure 12.11 seems hard to understand and read with the different meaning of each type of writing and numbering formats. Why organize the figure in concentric circles, when a table would probably be easier to understand? Also, The superposition of layers of roman numerals and letters and numbers makes this figure a little difficult to read. could the use of alternate codings be envisaged?	Partially accepted: Figure has been completely redrawn to make it easier to read. However the presentation as a figure rather than table has been retained, to show the multiple interconnections which would be lost in a table.	Government of France	Ministère de la Transition écologique et solidaire	France
60497	93	4	93	9	The role of CCU here is not fully correct, because it only considers the potential to capture the CO2, but not the fact that CCU can contribute to reinforce the transition to a more renewable energy system via power-to-x approach. I would suggest to add a sentence to differenciate this effect. The power to X approach enables the production of CO2-based fuels/e-fuels and chemicals using CO2 and H2 (e.g. Breyer et al., 2015, Sternberg and Bardow, 2015, Dimitrou et al., 2015, Fasihi et al., 2017, Shih et al. 2018, Anwar et al., 2020). •Breyer et al., 2015, Energy Procedia, 73, 182-189•Sternberg and Bardow, 2015, Energy Environ. Sci. 8, 389–400.•Shih et al., 2018, Joule, 2, 1925-1949.•Dimitrou et al., 2015, Energy Environ. Sci, 8, 1775-1789. •Anwar et al., 2020, J. of Env. Manag., 260, 110059.•Fasihi et al., 2017, J. of Cleaner Production, 224, 957-980.	Accepted: sentence and references added (but into the following paragraph, where it fits better)	Célia Sapart	Université Libre de Bruxelles / CO2 Value Europe	Belgium
83741	93	4	93	9	The role of CCU here is not fully correct, because it only considers the potential to capture the CO2, but not the fact that CCU can contribute to reinforce the transition to a more renewable energy system via power-to-x approach. I would suggest to add a sentence to differenciate this effect. The power to X approach enables the production of CO2-based fuels/e-fuels and chemicals using CO2 and H2 (e.g. Breyer et al., 2015, Sternberg and Bardow, 2015, Dimitrou et al., 2015, Fasihi et al., 2017, Shih et al. 2018, Anwar et al., 2020). •Breyer et al., 2015, Energy Procedia, 73, 182-189•Sternberg and Bardow, 2015, Energy Environ. Sci. 8, 389–400.•Shih et al., 2018, Joule, 2, 1925-1949.•Dimitrou et al., 2015, Energy Environ. Sci, 8, 1775-1789. •Anwar et al., 2020, J. of Env. Manag., 260, 110059.•Fasihi et al., 2017, J. of Cleaner Production, 224, 957-980.	Accepted. See response to comment 60497, identical comment	Christian Breyer	LUT University	Finland
27857	93	7	93	9	Delete "although the overall potential for CCS and CCU to contribute to mitigation in the electricity sector is now considered lower than was previously thought due to the increased uptake of renewables in preference to fossil fuel", considering the analysis on whether it is feasible to have a 100% RE based sector.	Accepted: sentence removed	Eleni Kaditi	Organization of the Petroleum Exporting Countries, OPEC	Austria
30583	93	7	93	8	The sentence says '.., although the overall potential for CCS and CCU to contribute to mitigation in the electricity sector is now considered lower than was previously thought due to the increased uptake of renewables in preference to fossil fuel.' It would be better to remove this sentence to be more policy neutral.	Accepted: sentence removed	Government of Japan	Climate Change Division - Ministry of Foreign Affairs	Japan
80697	93	9	93	10	Before providing a sink, BECCS must overcome the carbon deficit of several decades to a century. Danielle Venton, Core Concept: Can bioenergy with carbon capture and storage make an impact?, PNAS (2016); Leturcq, P. (2020) GHG Displacement Factors of Harvested Wood Products: the Myth of Substitution, Nature Scientific Reports 10:1–9; Mary S. Booth, Not carbon neutral: Assessing the net emissions impact of residues burned for bioenergy, Environ. Res. Lett. 13 (21 February 2018); Sterman J. D., et al. (2018) Does replacing coal with wood lower CO2 emissions? Dynamic lifecycle analysis of wood bioenergy, Envtl. Research Letters 13(015007):1–10, 1 ("We simulate substitution of wood for coal in power generation, estimating the parameters governing NPP and other fluxes using data for forests in the eastern US and using published estimates for supply chain emissions. Because combustion and processing efficiencies for wood are less than coal, the immediate impact of substituting wood for coal is an increase in atmospheric CO2 relative to coal. The payback time for this carbon debt ranges from 44–104 years after clear-cut, depending on forest type—assuming the land remains forest. Surprisingly, replanting hardwood forests with fast-growing pine plantations raises the CO2 impact of wood because the equilibrium carbon density of plantations is lower than natural forests. Further, projected growth in wood harvest for bioenergy would increase atmospheric CO2 for at least a century because new carbon debt continuously exceeds NPP. Assuming biofuels are carbon neutral may worsen irreversible impacts of climate change before benefits accrue. Instead, explicit dynamic models should be used to assess the climate impacts of biofuels."). Furthermore, even if BECCS were net zero or negative in the relevant next couple of decades, which it is not, large-scale biodiversity development requires vast land-use changes, which may have significant implications for food security and biodiversity. National Academies of Sciences, Engineering, and Medicine, Negative Emissions Technologies and Reliable Sequestration: A Research Agenda,10 (2019) ("Because food demand is expected to double by mid-century, repurposing a significant amount of current agricultural land to produce feedstocks for BECCS or for afforestation/reforestation might have a significant effect on food availability and food prices, with far-reaching effects on national security and biodiversity."). The IPCC Special Report on Climate Change and Land warns that high implementation of BECCS (11.3 GtCO2 yr-1 in 2050) could increase the population at risk of hunger by up to 150 million people and could have significant impacts on desertification and land degradation.	Reject. The statement "When coupled with energy recovery from biomass (BECCS), CCS can provide a carbon sink" is a statement of fact, and is not advocating for or against BECCS. BECCS is discussed in more detail in section 12.5.	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
80841	93	9	93	10	Before providing a sink, BECCS must overcome the carbon deficit of several decades to a century. Danielle Venton, Core Concept: Can bioenergy with carbon capture and storage make an impact?, PNAS (2016); Leturcq, P. (2020) GHG Displacement Factors of Harvested Wood Products: the Myth of Substitution, Nature Scientific Reports 10:1–9; Mary S. Booth, Not carbon neutral: Assessing the net emissions impact of residues burned for bioenergy, Environ. Res. Lett. 13 (21 February 2018); Sterman J. D., et al. (2018) Does replacing coal with wood lower CO2 emissions? Dynamic lifecycle analysis of wood bioenergy, Envtl. Research Letters 13(015007):1–10, 1 ("We simulate substitution of wood for coal in power generation, estimating the parameters governing NPP and other fluxes using data for forests in the eastern US and using published estimates for supply chain emissions. Because combustion and processing efficiencies for wood are less than coal, the immediate impact of substituting wood for coal is an increase in atmospheric CO2 relative to coal. The payback time for this carbon debt ranges from 44–104 years after clear-cut, depending on forest type—assuming the land remains forest. Surprisingly, replanting hardwood forests with fast-growing pine plantations raises the CO2 impact of wood because the equilibrium carbon density of plantations is lower than natural forests. Further, projected growth in wood harvest for bioenergy would increase atmospheric CO2 for at least a century because new carbon debt continuously exceeds NPP. Assuming biofuels are carbon neutral may worsen irreversible impacts of climate change before benefits accrue. Instead, explicit dynamic models should be used to assess the climate impacts of biofuels."). Furthermore, even if BECCS were net zero or negative in the relevant next couple of decades, which it is not, large-scale biodiversity development requires vast land-use changes, which may have significant implications for food security and biodiversity. National Academies of Sciences, Engineering, and Medicine, Negative Emissions Technologies and Reliable Sequestration: A Research Agenda,10 (2019) ("Because food demand is expected to double by mid-century, repurposing a significant amount of current agricultural land to produce feedstocks for BECCS or for afforestation/reforestation might have a significant effect on food availability and food prices, with far-reaching effects on national security and biodiversity."). The IPCC Special Report on Climate Change and Land warns that high implementation of BECCS (11.3 GtCO2 yr-1 in 2050) could increase the population at risk of hunger by up to 150 million people and could have significant impacts on desertification and land degradation.	Identical comment to previous comment 80697. Reject. The statement "When coupled with energy recovery from biomass (BECCS), CCS can provide a carbon sink" is a statement of fact, and is not advocating for or against BECCS. BECCS is discussed in more detail in section 12.5.	Gabrielle Dreyfus	Institute for Governance & Sustainable Development	United States of America
5553	93	20	93	20	After ren,ewable, add" or nuclear"	Accepted: Change made	Michel SIMON	Retraité/ Pdt d'association	France
24705	93	34	93	36	As the goal is to reduce CO2 emissions, the focus should be on all low-carbon electricity sources and not just renewables. Therefore we propose replacing "will depend on whether generation is fossil fuels or renewables based" with "will depend on whether generation is based on fossil fuels or low-carbon energy sources"	Accepted: Change made	Ann Jessica Johnson	FORATOM (European Atomic Forum)	Belgium
27859	93	34	93	36	Delete "The impact of electrification on electricity sector emissions will depend on whether generation is fossil fuels or renewables based.", as the role of CCUS is not considered in this argument.	Accepted: text changed to reflect "fossil fuels in the absence of CCS"	Eleni Kaditi	Organization of the Petroleum Exporting Countries, OPEC	Austria
121	93	40	93	44	The animal vs. plant protein discussion on dietary transition deserves a section in its own right. Currently, it is scattered all over the chapter, and the argumentation is rather diffuse.	Partially accepted: More detail has been provided in the food discussion in Section 12.4.3.1 and so no further text is added in this section	Harry Aiking	Vrije Universiteit, Institute for Environmental Studies	Netherlands
58069	93	40	93	44	Should have some acknowledgment here that not all calories are equal and a calorie of grain does not have the same nutritional content as a calorie of poultry, so there are potential health implications from switching between high protein sources of food to high carbohydrate sources.	Rejected: This point is considered to be already addressed in this paragraph. At no point in this chapter is it suggested that all calories are equal	Government of United State	U.S. Department of State	United States of America
22279	94	1	94	1	Box 12.2. The circular economy is considered here as a positivist perspective, while there is no clear definition of this paradigm, which sometimes means nothing more than an increase in industrial recycling on the other side of the world. Safeguards should be considered when talking about circular economy.	Accepted: Additional sentence to this effect added at the end of the box	Government of France	Ministère de la Transition écologique et solidaire	France
19555	94	22	94	22	Please revise as follows: "The notion of circular carbon economy (while not formally defined) is based on the idea that a combination of technologies may allow closing anthropogenic carbon cycles through CCUS (carbon used in durable products) or CDR (carbon durably removed from the atmosphere)." Reason: CCUS is not necessarily a form of CDR (see glossary definition of CCUS	Accepted: The wording has been changed to ensure that it does not suggest CCUS is a form of CDR. However the original wording has been retained as the proposed new wording changes the intended meaning	Matthias Honegger	Utrecht University, Perspectives climate research, IASS-Potsdam	Germany
61881	95	3	95	5	"One example here is the use of hydrogen as an energy carrier, which, when coupled with renewable energy, has potential for driving mitigation in energy, industry, transport, and buildings (see Box 12.3)." Replace "coupled with renewable energy" with "coupled with low-carbon energy" to be scientifically more accurate and technology neutral. Certainly low-carbon hydrogen can be produced with low-carbon energy, not just "renewable" energy.	Accepted: Change made	Rauli Partanen	Think Atom	Finland
65923	95	3	95	5	"One example here is the use of hydrogen as an energy carrier, which, when coupled with renewable energy, has potential for driving mitigation in energy, industry, transport, and buildings (see Box 12.3)." The contents of the Box 12.3 need to be changed to reflect my other comments on the costs of hydrogen. Replace "coupled with renewable energy" with "coupled with low-carbon energy".	Accepted: Change made	Eero Hirvijoki	Aalto University	Finland
5555	95	4	95	4	replace Renewables" by "low carbon sources"	Accepted: Change made	Michel SIMON	Retraité/ Pdt d'association	France

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
24707	95	4	95	4	Hydrogen produced via electrolysis: both renewable and nuclear power can be used in this process (see reference already used in the chapter: Bicer, Y., and Dincer, I. (2017). Life cycle assessment of nuclear-based hydrogen and ammonia production options: A comparative evaluation. International Journal of Hydrogen Energy, 42(33), 21559–21570. https://doi.org/https://doi.org/10.1016/j.ijhydene.2017.02.002). So we recommend replacing “coupled with renewable energy" with "coupled with low-carbon energy"	Accepted: Change made	Ann Jessica Johnson	FORATOM (European Atomic Forum)	Belgium
58071	95	5	95	5	There is only vague reference to Box 3. Presumably the cross-WG box was placed here because Chapter 12 is the most relevant place. It should enhance and be integrated with the chapter content. The chapter should not serve as mere repository.	Accepted: A sentence has been added to explain what is contained here, versus what is included in other chapters.	Government of United State	U.S. Department of State	United States of America
58073	95	15	95	15	The authors mention "rebound effects" without explaining the term.	Accepted: Have changed to ", with multiple potential cross-sectoral linkages"	Government of United State	U.S. Department of State	United States of America
61879	95	19	96	39	Please revise the contents of the Box 12.3. First, replace “renewable” with low-carbon to be scientifically more accurate and relevant from climate mitigation point of view. Further, include discussion on the potential of producing low-cost hydrogen with nuclear energy, as discussed in Kayfeci et at. 2019, https://doi.org/10.1016/B978-0-12-814853-2.00003-5; LucidCatalyst, 2021, https://www.lucidcatalyst.com/hydrogen-report and in UNECE 2021 https://unece.org/sustainable-energy/publications/nuclear-entry-pathways	Partly accepted. Nuclear is added as a source for hydrogen. The more detailed discussion of the literature is beyond the scope of this box that summerizes findings from earlier chapters.	Rauli Partanen	Think Atom	Finland
65925	95	22	95	24	"In Chapter 6 of this report, it is shown that hydrogen can be produced with low carbon impact from fossil fuels (Section 6.4.2.7), renewable electricity (Section 6.4.5.1), or biomass (Section 6.4.2.6)." How about nuclear energy? In Chapter 6, the reference (Graves et al., 2011, https://doi.org/10.1016/j.rser.2010.07.014) reports that "[t]he dominant costs of the process are the electricity cost and the capital cost of the electrolyzer, and this capital cost is significantly increased when operating intermittently (on renewable power sources such as solar and wind)." The reference (Kayfeci et at. 2019, https://doi.org/10.1016/B978-0-12-814853-2.00003-5) lists hydrogen from biomass and nuclear at most half the cost of hydrogen from solar or wind. The report (LucidCatalyst, 2021, https://www.lucidcatalyst.com/hydrogen-report) lists hydrogen from existing nuclear PWR technology at less than $2/kg and from GENIV technology at $1/kg or less. Revise the paragraph accordingly.	Partly accepted. Nuclear is added as a source for hydrogen. The more detailed discussion of the literature is beyond the scope of this box that summerizes findings from earlier chapters.	Eero Hirvijoki	Aalto University	Finland
5557	95	24	95	45	replace Renewables" by "low carbon sources" on lines 24 and 45	Noted. In line with other comments, 'nuclear energy' was added.	Michel SIMON	Retraité/ Pdt d'association	France
24709	95	24	95	24	Hydrogen produced via electrolysis: both renewable and nuclear power can be used in this process (see reference already used in the chapter: Bicer, Y., and Dincer, I. (2017). Life cycle assessment of nuclear-based hydrogen and ammonia production options: A comparative evaluation. International Journal of Hydrogen Energy, 42(33), 21559–21570. https://doi.org/https://doi.org/10.1016/j.ijhydene.2017.02.002). So we recommend replacing “renewable electricity" with "low-carbon electricity"	Rejected. Nuclear energy is certainly a potential source for hydrogen (as is now included in the first paragraph of this box), but the attention globally is now more on hydrogen from renewable sources (and blue hydrogen).	Ann Jessica Johnson	FORATOM (European Atomic Forum)	Belgium
24711	96	3	96	4	Hydrogen produced via electrolysis: both renewable and nuclear power can be used in this process (see reference already used in the chapter: Bicer, Y., and Dincer, I. (2017). Life cycle assessment of nuclear-based hydrogen and ammonia production options: A comparative evaluation. International Journal of Hydrogen Energy, 42(33), 21559–21570. https://doi.org/https://doi.org/10.1016/j.ijhydene.2017.02.002). So we recommend replacing “When it comes to the production of low-carbon hydrogen, most attention is for the production out of electricity from renewable sources via electrolysis, so-called ‘green hydrogen’. "When it comes to the production of low-carbon hydrogen, most attention is for the production out of electricity from low-carbon sources via electrolysis, so-called ‘green hydrogen"	Rejected. Nuclear energy is certainly a potential source for hydrogen (as is now included in the first paragraph of this box), but the attention globally is now more on hydrogen from renewable sources (and blue hydrogen).	Ann Jessica Johnson	FORATOM (European Atomic Forum)	Belgium
58075	96	3	96	3	Start new paragraph at "When it comes to the production of low-carbon hydrogen ..."	Accepted.	Government of United State	U.S. Department of State	United States of America
61883	96	3	96	4	"When it comes to the production of low-carbon hydrogen, most attention is for the production out of electricity from renewable sources via electrolysis [..]" Please replace “renewable” with “low -carbon” to be scientifically more accurate and relevant from climate change point of view. This includes nuclear power, which is a very potent source of low-carbon hydrogen (is discussed in my previous comments).	Noted. In line with other comments, 'nuclear energy' was added.	Rauli Partanen	Think Atom	Finland
65927	96	3	96	4	"When it comes to the production of low-carbon hydrogen, most attention is for the production out of electricity from renewable sources via electrolysis [..]" It would be fair to mention also hydrogen from nuclear, for the reasons mentioned in my previous comment.	Rejected. Nuclear energy is certainly a potential source for hydrogen (as is now included in the first paragraph of this box), but the attention globally is now more on hydrogen from renewable sources (and blue hydrogen).	Eero Hirvijoki	Aalto University	Finland
74253	96	3	96	5	This paragraph should be revised so that it is not renewables centric. Green hydrogen produced by carbon free nuclear is exactly the same as hydrogen produced by renewables. The point is to manufacture hydrogen using carbon free energy. Additionally, due to its energy density, nuclear can produce significantly more hydrogen with a smaller geographical footprint.	Rejected. Nuclear energy is certainly a potential source for hydrogen (as is now included in the first paragraph of this box), but the attention globally is now more on hydrogen from renewable sources (and blue hydrogen).	Jeffrey Merrifield	Pillsbury Law Firm	United States of America
61885	96	11	96	14	It would be prudent to mention the expected costs for hydrogen production with nuclear. For example the LucidCatalyst 2021 Hydrogen Report (https://www.lucidcatalyst.com/hydrogen-report) estimates a cost of $0.9-1.1/kg translating to $27-33/MWh for hydrogen produced with nuclear energy by 2030, which is significantly low and therefore should be mentioned.	Rejected. Nuclear energy is certainly a potential source for hydrogen (as is now included in the first paragraph of this box). The LucidCatalyst report is very informative, but is not explicit on timescales of the deployment of technologies.	Rauli Partanen	Think Atom	Finland

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
65929	96	11	96	14	In mentioning the price expectations for hydrogen production with renewables, it would be fair to mention also the expected costs for hydrogen production with nuclear. The LucidCatalyst 2021 Hydrogen Report (https://www.lucidcatalyst.com/hydrogen-report) estimates a cost of $0.9-1.1/kg translating to $27-33/MWh for hydrogen produced with nuclear energy by 2030. This is a lower number than the ones provided for hydrogen from renewable energy sources and should therefore be mentioned.	Rejected. Nuclear energy is certainly a potential source for hydrogen (as is now included in the first paragraph of this box). The LucidCatalyst report is very informative, but is not explicit on timescales of the deployment of technologies.	Eero Hirvijoki	Aalto University	Finland
58077	96	20	96	12	"… coal prices typically are a factor 2 lower than that …" What does a "factor 2 lower" mean? This should be rewritten and defined if applicable.	Partly accepted. Statement is made less precise, reflecting variation in energy prices in different regions.	Government of United State	U.S. Department of State	United States of America
11003	97	21	97	21	delete ")" as "Karplus et al. 2013; Section 12.2)"	Accepted. Editorial fixed	Dong-Woon NOH	Korea Energy Economics Institute	Republic of Korea
16601	97	21	97	21	delete ")" as "Karplus et al. 2013; Section 12.2)"	Accepted. Editorial fixed	Government of Republic of K	Korea Meteorological Administration (KMA)	Republic of Korea
27861	98	9	98	10	Delete "Example is the integration between smart agriculture and low carbon energy.", as issues related to reliability, affordability and accessibility are not taken into consideration in this generic example.	Rejected. The example is meant to demonstrate the integrated planning and cross-sectoral coordination between agriculture and energy. The question of energy access, reliability and cost is valid but irrelevant to the exmaple and the context.	Eleni Kaditi	Organization of the Petroleum Exporting Countries, OPEC	Austria
11005	98	20	98	20	change "spillo-vers" to "spill-overs"	Accepted. Editorial fixed	Dong-Woon NOH	Korea Energy Economics Institute	Republic of Korea
16603	98	20	98	20	change "spillo-vers" to "spill-overs"	Accepted. Editorial fixed	Government of Republic of K	Korea Meteorological Administration (KMA)	Republic of Korea
58079	98	21	98	21	Article mismatch between "an" and "approaches"	Accepted. Editorial fixed	Government of United State	U.S. Department of State	United States of America
58081	98	22	98	23	Here, and elsewhere, how do authors take account of an "unanticipated outcome"? Somewhere, the term should be clarified to note that policies that focus on sectoral or national mitigation may have impacts outside the sector or nation which offset to some degree the mitigation that was planned on being achieved with the policy.	Rejected. What is meant by "unanticipated outcomes" is clear from the context and no need for specific definition of the term. As for how the authors deal with that the paragraph says clearly there is a need for a holistic approach that takes into account synergies and trade-offs.	Government of United State	U.S. Department of State	United States of America
77655	98	25	98	37	We must acknowledge that we are facing real limits to trade offs (IPBES 2019; The Economics of Biodiversity, the Dasgupta Review 2021; The Nexus Report: Nature Based Solutions to the Biodiversity and Climate Crises, Barber C.V, Petersen R., Young V, Mackey B, Kormos C, 2020). We can't keep losing natural ecosystems in good condition. We must act quickly to restore ecological health and function in most agricultural and natural ecosystems and we must maximise the adaptive capacity of ecosystems. These imperatives should frame and help parties prioritise all mitigation action in the AFOLU sector.	Taken into account. text slightly revised to strength the policy trade-offs involved. A citation of Dasgupta report is also made.	Virginia Young	Australian Rainforest Conservation Society	Australia
10823	98	39	98	39	The Sahara Forest Project is quite interesting. However, it seems that nothing much is happening recently. The quoted reference (Hoff et al) was submitted in the fall of 2018. Is the projet encountering difficulties?	Noted. Not aware of specific difficulties facing the project and it seems performing well as vegtables from the project reached Norway markets.	Philippe Waldteufel	CNRS	France
58083	99	36	101	25	It would be helpful to define and discuss the "pollution haven hypothesis" in Section 12.6.3.	Rejected. Discussion of pollution haven and various forms of carbon leakage are described in detail in Chapter 13. This subsection addresses only cross-sectroal aspects of carbon leakage	Government of United State	U.S. Department of State	United States of America
77657	99	37	99	43	Reflection on the relevance of the IPBES analysis of key levers for transformational change would be helpful in terms of looking for synergies.(See IPBES Summary for Policy makers 2019).	Rejected. This comment is irelevant to this subsection. The focus here is on carbon leakage	Virginia Young	Australian Rainforest Conservation Society	Australia
86847	99	37	101	21	The whole Section 12.6.3.1. referred to "carbon leakage" has no scientific basis and no multilateral consensus, and it includes ideas that go beyond international agreements and inconsistent with WTO rules. Thus we propose to delete the whole section till line 21 in page 101.	Rejected. The text as well as the section on carbon leakage in Chapter 13 are based on the set of academic literature that explores the phenomenon of carbon leakage. They summarize the results provided by this literature and thus have the scientific basis. There are various ideas to address carbon leakage, and some of them are not supported by international consensus. This however, doesn't mean that the problem of carbon leakage shouldn't be discussed.	Government of Argentina	Ministry of Environment and Sustainable development of Argentina	Argentina
15289	100	2	100	3	Carbon leakage is not caused by the different national climate policies, but probably by the national resource endowment and industrial structure. It is suggested to further verify and modify the statement.	Rejected. Flows of emissions embodied in international trade are no doubt caused by national resource endownment, industrial structure and other factors determining the geography of international trade. However, carbon leakage is a narrower term which addresses changes in trade flows of carbon-intensive goods as a result of climate policies. In this sense this term was used in previous IPCC assessment reports as well as in academic literature	Government of China	China Meteorological Administration	China
3545	100	3	100	3	Please, add reference (Allevi et al 2017): Elisabetta Allevi, Giorgia Oggioni, Rossana Riccardi, Marco Rocco. Evaluating the carbon leakage effect on cement sector under different climate policies, Journal of Cleaner Production, Volume 163, 2017, Pages 320-337, https://doi.org/10.1016/j.jclepro.2015.12.072.	Rejected. This is an important paper. However, this particular subsection addresses only cross-sectoral aspects of carbon leakage. Carbon leakage within sectors is addressed in Chapter 13	Miguel Angel Sanjuán	IECA	Spain
10437	100	3	100	3	Please, add reference (Allevi et al 2017): Elisabetta Allevi, Giorgia Oggioni, Rossana Riccardi, Marco Rocco. Evaluating the carbon leakage effect on cement sector under different climate policies, Journal of Cleaner Production, Volume 163, 2017, Pages 320-337, https://doi.org/10.1016/j.jclepro.2015.12.072.	Rejected. This is an important paper. However, this particular subsection addresses only cross-sectoral aspects of carbon leakage. Carbon leakage within sectors is addressed in Chapter 13	Aniceto Zaragoza	Oficemen	Spain
11593	100	3	100	3	Please, add reference (Allevi et al 2017): Elisabetta Allevi, Giorgia Oggioni, Rossana Riccardi, Marco Rocco. Evaluating the carbon leakage effect on cement sector under different climate policies, Journal of Cleaner Production, Volume 163, 2017, Pages 320-337, https://doi.org/10.1016/j.jclepro.2015.12.072.	Rejected. This is an important paper. However, this particular subsection addresses only cross-sectoral aspects of carbon leakage. Carbon leakage within sectors is addressed in Chapter 13	PEDRO MORA PERIS	UNIVERSITY	Spain

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
27863	100	26	100	29	Delete "Davis et al. (2011) notice that given the high level of geographical concentration of fossil fuels production and processing, regulation at the wellhead, mine mouth, or refinery might minimise transaction costs of global climate policy and the opportunities for leakage."	Partially accepted. This sentence is quite relevant to the context and important for describing value-chains related aspects of carbon leakage. The sentence however was reworded to make it clearer and to link it better to the other text: "Davis et al. (2011) notice that the analysis of value chains gives an opportunity to find the point where regulation would be the most efficient and the least vulnerable to leakage. For instance, transaction costs of global climate policy and the risks of leakage may be reduced if emissions are regulated at the stage of extraction as there are much fewer agents involved into this process than in burning of fossil fuels or consumption of energy-intensive goods."	Eleni Kaditi	Organization of the Petroleum Exporting Countries, OPEC	Austria
3547	100	31	100	31	Please, add the following text: "Allevi et al concluded that the Italian and the European cement markets are exposed to carbon leakage and this exposure is higher for coastal plants especially when the regulation is more stringent (Allevi et al 2017)." Elisabetta Allevi, Giorgia Oggioni, Rossana Riccardi, Marco Rocco. Evaluating the carbon leakage effect on cement sector under different climate policies, Journal of Cleaner Production, Volume 163, 2017, Pages 320-337, https://doi.org/10.1016/j.jclepro.2015.12.072.	Rejected. This particular subsection addresses only cross-sectoral aspects of carbon leakage. Carbon leakage within sectors is addressed in Chapter 13	Miguel Angel Sanjuán	IECA	Spain
10439	100	31	100	31	Please, add the following text: "Allevi et al concluded that the Italian and the European cement markets are exposed to carbon leakage and this exposure is higher for coastal plants especially when the regulation is more stringent (Allevi et al 2017)." Elisabetta Allevi, Giorgia Oggioni, Rossana Riccardi, Marco Rocco. Evaluating the carbon leakage effect on cement sector under different climate policies, Journal of Cleaner Production, Volume 163, 2017, Pages 320-337, https://doi.org/10.1016/j.jclepro.2015.12.072.	Rejected. This particular subsection addresses only cross-sectoral aspects of carbon leakage. Carbon leakage within sectors is addressed in Chapter 13	Aniceto Zaragoza	Oficemen	Spain
11595	100	31	100	31	Please, add the following text: "Allevi et al concluded that the Italian and the European cement markets are exposed to carbon leakage and this exposure is higher for coastal plants especially when the regulation is more stringent (Allevi et al 2017)." Elisabetta Allevi, Giorgia Oggioni, Rossana Riccardi, Marco Rocco. Evaluating the carbon leakage effect on cement sector under different climate policies, Journal of Cleaner Production, Volume 163, 2017, Pages 320-337, https://doi.org/10.1016/j.jclepro.2015.12.072.	Rejected. This particular subsection addresses only cross-sectoral aspects of carbon leakage. Carbon leakage within sectors is addressed in Chapter 13	PEDRO MORA PERIS	UNIVERSITY	Spain
87067	100	34	100	40	A consumption charge would be even more difficult to implement than a carbon border adjustment mechanism. It would require a proper accounting system of carbon intensity of products through the value chain, unlike a CBAM which would focus on the entry of basic materials in the EU.	Accepted. This sentence was reworded: "This proposal is very close to border carbon adjustment introduced in the EU and described in more details in Chapter 13."	Philippe Wen	Ministère de l'Économie, des Fi	France
22281	100	36	100	40	We suggest to consider that a consumption charge would be even more difficult to implement than a carbon border adjustment mechanism. It would require a proper accounting system of carbon intensity of products through the value chain, unlike a CBAM which would focus on the entry of basic materials in the EU.	Accepted. This sentence was reworded: "This proposal is very close to border carbon adjustment introduced in the EU and described in more details in Chapter 13."	Government of France	Ministère de la Transition écologique et solidaire	France
46239	100	39	100	39	Please delete: "the same legal and political obstacles", and replace: "such charges on the consumption could in principle be adjusted at the borders, whereas other carbon border adjustments based on Emission Trading Schemes face additional legal and political obstacles" COMMENT: The pricing of consumption is the "ordinary" form of border adjustment (destination principle), not the other way around. It is similar to the Value Added Taxation, which is adjusted at borders in accordance with WTO Law.	Accepted. This sentence was reworded: "This proposal is very close to border carbon adjustment introduced in the EU and described in more details in Chapter 13."	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
58085	100	47	100	47	Change "scale of these with" to "scale of these effects with"	Accepted. Editorials fixed.	Government of United State	U.S. Department of State	United States of America
58087	101	3	101	3	"effect" should be "effects"	Accepted. Editorials fixed.	Government of United State	U.S. Department of State	United States of America
58089	101	6	101	6	"play more" should be "play a more"	Accepted. Editorials fixed.	Government of United State	U.S. Department of State	United States of America
58091	101	7	101	7	"concerns transport" should be "concerns the transport"	Accepted. Editorials fixed.	Government of United State	U.S. Department of State	United States of America
70619	101	18	101	21	rather speculative Is there any beginning of proof or quantitative assessment of this assertion?	Accepted. Quantitative assessment was added: According to Zhang et al. (2020) for China, the decrease of the degree of global value chain participation (which ranges from 0 to 1) by 0.1 would lead to the increase of gross carbon intensity of China's exports by 11.7%.	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
58093	101	19	101	19	"it will make each country to build" should be either "it will make each country build" or "it will require each country to build"	Accepted. Editorials fixed.	Government of United State	U.S. Department of State	United States of America
27865	101	28	101	29	Delete "Regulation of emissions of industrial producers decreases the demand for fossil fuels that would reduce prices and encourage the rise of fossil fuel consumption in regions with no or weaker climate policies", as fundamental factors could affect prices which are not taken into consideration in this argument.	Partially accepted. "Other things being equal" was added to this sentence	Eleni Kaditi	Organization of the Petroleum Exporting Countries, OPEC	Austria
58095	101	31	101	31	"channel" should be "channels"	Rejected. It is a single channel decribed in the previous sentence. The article was added: "the energy channel"	Government of United State	U.S. Department of State	United States of America
58097	101	31	101	33	"16% of the additional emissions reductions" means what exactly? Compared to what?	Taken into account. Compared to no policy scenario. If a pioneering country introduces climate policy, it reduces emissions but some (less than 16%) of its emissions reduction leaks to other countries. The phrase was reworded: "They come to the conclusion that the leakage rate through the energy channel is less than 16% of the emission reductions of regions who introduce climate policies first."	Government of United State	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
58099	101	32	101	32	"come to conclusion" should be "come to the conclusion"	Accepted. Editorials fixed.	Government of United State	U.S. Department of State	United States of America
27867	101	38	102	16	Delete these four paragraphs on 'green paradox', as this analysis is not supported by past evidence.	Rejected. These paragraphs contain both ex-ante and ex-post estimates of green paradox from academic literature. Most of these estimates show that green paradox is statistically significant at least in some of its forms. The remaining level of uncertainty in studying this subject is reflected by the stated degree of evidence and degree of agreement. In this case - robust evidence, medium agreement	Eleni Kaditi	Organization of the Petroleum Exporting Countries, OPEC	Austria
58101	101	45	101	45	"way" should be "ways"	Accepted. Editorial fixed.	Government of United State	U.S. Department of State	United States of America
58103	103	1	103	1	Awkward phrasing with "for them such"	Accepted. section 12.6.3.3 now moved to chapter 16 where the text material will be revised and incorporated taking on board this and other comments.	Government of United State	U.S. Department of State	United States of America
58105	103	4	103	6	But pioneering the transformation was still the more costly approach.	Taken into account. Section 12.6.3.3 now moved to chapter 16. Your comment will be passed to chapter 16 to address.	Government of United State	U.S. Department of State	United States of America
46241	103	10	104	40	When evaluating the implications of cross-sectoral mitigation finance in chapter 12.6.4, the inclusion of nature-based solution seems appropriate, as they have a potential to simultaneously provide benefits for biodiversity, climate and sustainable development, while they are still underfinanced. The financing of NbS is covered in chapter 15 (p.88f) and a reference to this chapter could be provided here.	Accepted. Refence to NBS and chapter 15 is added in the next pargraph.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
61887	103	31	103	34	"GHG reductions activities eligible to MDB mitigation are limited to those compatible with low-emission pathways recognising the importance of long term structural changes, such as the shift in energy production to renewable energy technologies and the modal shift to low-carbon modes of transport leveraging both green eld and energy efficiency projects." Is only the shift to renewable energy eligible for financing from MDBs? Is nuclear energy, as a clean low-carbon energy source, not eligible? If it is, then rephrase "shift in energy production to renewable energy [..]" into "shift in energy production to low-carbon energy [..]". If it is not, recommend that it be included since it is our second-largest source of low-carbon energy and for example supports all the SDG's, as discussed in UNECE 2021 https://unece.org/sustainable-energy/publications/nuclear-entry-pathways	Accepted. "Renewable energy technologies" changed to "low-carbon energy technologies".	Rauli Partanen	Think Atom	Finland
65931	103	31	103	34	"GHG reductions activities eligible to MDB mitigation are limited to those compatible with low-emission pathways recognising the importance of long term structural changes, such as the shift in energy production to renewable energy technologies and the modal shift to low-carbon modes of transport leveraging both greenfield and energy efficiency projects." Is only the shift to renewable energy eligible for financing from MDBs? Is nuclear energy, as a clean source, not eligible? If it is, then rephrase "shift in energy production to renewable energy [..]" into "shift in energy production to low-carbon energy [..]". If nuclear is not eligible, discuss why it is not, and how to revert the situation.	Accepted. "Renewable energy technologies" changed to "low-carbon energy technologies".	Eero Hirvijoki	Aalto University	Finland
58107	103	35	103	35	"Transport" and "Energy" should have lower case t and e.	Accepted. editorials fixed.	Government of United State	U.S. Department of State	United States of America
10825	103	39	103	42	The literature? Looking through (Mendez and Houghton 2020), no effort to facilitate cross cross-sectoral solutions is suggested.	Accepted. Sentence referencing Mendez and Houghton 2020 deleted.	Philippe Waldteufel	CNRS	France
58109	104	4	104	4	"spend" should be "spent"	Accepted. Editorial fixed.	Government of United State	U.S. Department of State	United States of America
22283	104	25	104	29	It is not just about financial resources, but also about enabling environments (see chapter 15): institutions, stakeholders' ownership, policies	Taken into account. Sentence revised to state that availability and access to finance are "among" the major barriers.	Government of France	Ministère de la Transition écologique et solidaire	France
87069	104	25	104	29	It is not just about financial resources, but also about enabling environments (see chapter 15): institutions, stakeholders' ownership, policies	Taken into account. Sentence revised to state that availability and access to finance are "among" the major barriers.	Philippe Wen	Ministère de l'Économie, des Fi	France
12093	104	26	104	36	It is suggested that the reference to the potential overreliance on technologies that are still in their infancy reference Solar Radiation Modification as one such technique and that this be cross referenced to the discussion of SRM in Chap 14.	Reject. SRM is outside the mandate of chapter 12. It is addressed as as a cross-working-groups theme and discussed as mentioned in the comment by chapter 14.	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
12103	105	5	105	6	Whilst CDR research should be responsibly incentivised, research gives rise to important governance issues. It is suggested these are addressed here. For example, it is unclear how knowledge gaps will be identified, research agenda set, and funding will be secured and provided to appropriate researchers. Other important elements of the CDR research governance include the underpinning processes informing the flow of funds to and from, public or private, funders and the provision of and access to data or research resources including infrastructure to all.	Taken into account. Literature on dedicated research, development and demonstration of CDR is scarce, all the more for a broader range, going beyond method specific approches. We added more literature beyond the seminal Nemet et al. 2018 (Fajardy et al., Burns/Corbett, Goll et al.), some of which covers only a cluster of methods (ocean-based) or a single method (EW).	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
12095	105	9	105	15	Suggest reference to the Convention on Biodiversity (CBD) which has focussed on ocean fertilisation activities when, at its 9th conference, it adopted decision IX/16 C that urged signatories 'to ensure that ocean fertilization activities do not take place until there is an adequate scientific basis on which to justify such activities, including assessing associated risks, and a global, transparent and effective control and regulatory mechanism is in place for these activities; with the exception of small scale scientific research studies within coastal waters'. (CBD, 2008, p.7). In 2010, with a view to protecting biodiversity, the CBD went further when it invited Parties and other Governments, as well as relevant organisations and processes to consider its guidance (X/33(8)(w)) that 'no climate-related geo-engineering activities that may affect biodiversity take place, until there is an adequate scientific basis on which to justify such activities and appropriate consideration of the associated risks for the environment and biodiversity and associated social, economic and cultural impacts…..' (CBD, 2010, p.5). The CBD recommendation did not include small-scale scientific research studies undertaken in controlled settings that would help identify the potential impacts on the environment. Subsequently, the COPs XI and XIII reaffirmed this decision. At the 13th Conference of Parties additional guidance was agreed in Decision XIII/4 which states that 'more transdisciplinary research and sharing of knowledge among appropriate institutions is needed in order to better understand the impacts of climate-related climate engineering on biodiversity and ecosystem functions and services, socio-economic, cultural and ethical issues and regulatory options'. Whilst the CBD position is not binding, country participation is not universal (e.g. the US has signed but not ratified) and it only relates to the conservation of biodiversity, the sustainable use of biological resources and the fair and equitable sharing of benefits arising from genetic resources. The CBD's own Technical Series 66 publication states "The 2010 CBD decision on geoengineering is not legally binding. However, the decision is important for a global governance framework because of the consensus of the 193 Parties it represents and the political signal it sends." (CBD, 2012). The CBD evocation of the Precautionary Principle may, however, be an important demonstration of the willingness of parties to international law to take such measures in time. However, the limitations of the CBD also highlight that individual extant protocols and conventions as currently constructed could only form an incomplete basis for global regulation, which forms an important element of governance, because they each apply to discrete, specific topics and	Rejected. CBD does not contain "hard rules", and the decisions cited here are not legally binding, which often leads to confusion when literature refers to CBD. Paragraph on international CDR governance refers to section 14.4.5 where there is a broader assessment of international treaties and agreements containing elements related to CDR, where the CBD is included (highlighting again that this is mainly oabout a series of non-binding COP decisions)	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
12101	105	18	106	39	Some CDR techniques described do not have the capability to sequester captured carbon durably or permanently, endangering reversing the gains from achieved CDR. This issue creates important research, engineering and governance challenges (NAS, 2020). For example: the long-term management of sequestered carbon over century timescales; the prevention of leakage from hard to reach or challenging environments; and, financing or incentives (NAS, 2020). Currently, aside from agreements relating to sub-sea storage (see the Convention on the Prevention of Marine Pollution and the London Protocol below) mentioned in the text, these issues have not been resolved. It is suggested that an additional paragraph be inserted to address sequestration governance. REFERENCE NAS, 2015. Climate Intervention: Carbon Dioxide Removal and Reliable Sequestration. Washington, DC: The National Academies Press. https://doi.org/10.17226/18805.	Taken into account. In line with the focus on timescales of storage in the Cross Chapter Box on CDR we highlight governance challenges around securing long-term storage, by including more text on MRV, accounting, liabilities.	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
22289	105	18	105	18	this whole section would benefit to be linked better with chapter 14 dedicated to governance of CDR and SRM, as the paragraph on CDR in chapter 14 is rather short; depending on reference to chapter 12 or 14, the reader could have a rather complete or partial information on CDR governance.	Taken into account. This section has been expanded a little on international governnace dimensions (mostly accounting/MRV, technology transfer and supply cahin management) and does now refer explicitly to section 14.4.5, where the international (treaty-based) governance of CDR is dealt with in much more detail. This is the intended division of labor between chapters 12 and 14	Government of France	Ministère de la Transition écologique et solidaire	France
54381	105	19	105	36	Large overlaps with 12.3.1.	Taken into account, and resolved, now that this section is also part of 12.3. Many of the concerns voiced and challenges noted have now been listed in the opening part f 12.3 (right after the cross-chapter box) to not make them appear as an "afterthought", and since 12.3.1 and 12.3.2. already deal with them. To avoid overlap, not all concerns and challenges noted are listed here again	Sabine Fuss	MCC Berlin	Germany
54383	105	19			For Section 12.7.1 it needs to be made much more transparent how little evidence there is: Much of the cited literature here is opinion pieces, perspectives, commentaries, synthesis articles of the same…	Taken into account. We do not refer to article types but highlight that the literature started moving form being purely conceptual to being more empirically grounded, as actual CDR governance and policymaking starts to emerge. But since literature lags on-the-ground developments, we also included a case-study box on the UK	Sabine Fuss	MCC Berlin	Germany
70621	105	19	105	47	the beginning up to line 46 is redundant with what has been said previously and could be shortened or even deleted; from line 46 on, the discourse is really new	Accepted. There was indeed much overlap in lines 19-36. We now expand on basic rationales for CDR (as presented in Cross-Chapter Box) with additional material, but keep challenges and concerns mainly in the opening section of 12.3	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
22285	105	22	105	23	Concerning the statement "are impossible to achieve without CDR" we recommand to rephrase.This wording suggests that these targets could ge achieved effectively with CDR technologies. Except A/R, most of the technologies presented above in the chapter are still at the research/experiment stage. Their capacity to deliver the required level of carbon capture is not yet proven. I suggest a sentence reflecting this uncertainty	Taken into account. Argument clarified, consistent with the Cross-Chapter Boxes on CDR (ch12) and Net-Zero (ch3). If a country sets a net-zero target (like many countries already did), then this automatically implies CDR (otherwise, target would not be 'net' zero emissions, but simply zero emissions). This does not necessarily imply large-scale CDR, since it could also be achieved with a low level of residual emissions	Government of France	Ministère de la Transition écologique et solidaire	France

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
22287	105	24	105	24	Concerning the term "hard to abate emissions", this is not a robust concept as these emissions are hard-to-abate in a given social political context. Residual emissions should be defined as emissions that remain when absolutely everything has been implemented to offset them.	Taken into account. The category "residual emissions" indeed needs more exploration, but literature is missing, not only on the link with CDR (see section 2.7.3 for residual emissions in context of IAMs). Here it is simply used for everything that is left at the point of net-zero (and would need to be lowered further after net-zero, in case a country wants to achieve net negative). The qualifyer "hard-to-abate" is not attached to the emissions anymore, but a similar one "hard-to-tranisition") to sectors where such emissions are to be expected. The criterion "when absolutely everything has been implemented" cannot be operationlized scientifically, when talking about 2050	Government of France	Ministère de la Transition écologique et solidaire	France
58111	105	26	105	36	In the critique of CDR, the section does not include the potential for market disruptions such as the potential for increased unemployment in some sectors, decreases in the standard of living, and/or a reduction in GDP that may be unevenly distributed across countries.	Rejected. This is not a critique that has been mentioned in the literature	Government of United State	U.S. Department of State	United States of America
80699	105	26	105	36	BECCS is further complicated by the fact that it is not carbon neutral in the near-term—with a carbon deficit for many years, generally several decades to a century—that is crucial for mitigating emissions and avoiding hitting the 1.5°C mark. Danielle Venton, Core Concept: Can bioenergy with carbon capture and storage make an impact?, PNAS (2016); Leturcq, P. (2020) GHG Displacement Factors of Harvested Wood Products: the Myth of Substitution, Nature Scientific Reports 10:1–9; Mary S. Booth, Not carbon neutral: Assessing the net emissions impact of residues burned for bioenergy, Environ. Res. Lett. 13 (21 February 2018); Sterman J. D., et al. (2018) Does replacing coal with wood lower CO2 emissions? Dynamic lifecycle analysis of wood bioenergy, Envtl. Research Letters 13(015007):1–10, 1 ("We simulate substitution of wood for coal in power generation, estimating the parameters governing NPP and other fluxes using data for forests in the eastern US and using published estimates for supply chain emissions. Because combustion and processing efficiencies for wood are less than coal, the immediate impact of substituting wood for coal is an increase in atmospheric CO2 relative to coal. The payback time for this carbon debt ranges from 44–104 years after clear-cut, depending on forest type—assuming the land remains forest. Surprisingly, replanting hardwood forests with fast-growing pine plantations raises the CO2 impact of wood because the equilibrium carbon density of plantations is lower than natural forests. Further, projected growth in wood harvest for bioenergy would increase atmospheric CO2 for at least a century because new carbon debt continuously exceeds NPP. Assuming biofuels are carbon neutral may worsen irreversible impacts of climate change before benefits accrue. Instead, explicit dynamic models should be used to assess the climate impacts of biofuels."). Furthermore, even if BECCS were net zero or negative in the relevant next couple of decades, which it is not, large-scale biodiversity development requires vast land-use changes, which may have significant implications for food security and biodiversity. National Academies of Sciences, Engineering, and Medicine, Negative Emissions Technologies and Reliable Sequestration: A Research Agenda,10 (2019) ("Because food demand is expected to double by mid-century, repurposing a significant amount of current agricultural land to produce feedstocks for BECCS or for afforestation/reforestation might have a significant effect on food availability and food prices, with far-reaching effects on national security and biodiversity."). The IPCC Special Report on Climate Change and Land warns that high implementation of BECCS (11.3 GtCO2 yr-1 in 2050) could increase the population at risk of hunger by	Noted. No action demanded, and this is obviously not the section to disucss the downsides of BECCS. Thanks for making the effort of copying and pasting the same/similar comment wherever BECCS is mentioned in this report	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
80843	105	26	105	36	BECCS is further complicated by the fact that it is not carbon neutral in the near-term—with a carbon deficit for many years, generally several decades to a century—that is crucial for mitigating emissions and avoiding hitting the 1.5°C mark. Danielle Venton, Core Concept: Can bioenergy with carbon capture and storage make an impact?, PNAS (2016); Leturcq, P. (2020) GHG Displacement Factors of Harvested Wood Products: the Myth of Substitution, Nature Scientific Reports 10:1–9; Mary S. Booth, Not carbon neutral: Assessing the net emissions impact of residues burned for bioenergy, Environ. Res. Lett. 13 (21 February 2018); Sterman J. D., et al. (2018) Does replacing coal with wood lower CO2 emissions? Dynamic lifecycle analysis of wood bioenergy, Envtl. Research Letters 13(015007):1–10, 1 ("We simulate substitution of wood for coal in power generation, estimating the parameters governing NPP and other fluxes using data for forests in the eastern US and using published estimates for supply chain emissions. Because combustion and processing efficiencies for wood are less than coal, the immediate impact of substituting wood for coal is an increase in atmospheric CO2 relative to coal. The payback time for this carbon debt ranges from 44–104 years after clear-cut, depending on forest type—assuming the land remains forest. Surprisingly, replanting hardwood forests with fast-growing pine plantations raises the CO2 impact of wood because the equilibrium carbon density of plantations is lower than natural forests. Further, projected growth in wood harvest for bioenergy would increase atmospheric CO2 for at least a century because new carbon debt continuously exceeds NPP. Assuming biofuels are carbon neutral may worsen irreversible impacts of climate change before benefits accrue. Instead, explicit dynamic models should be used to assess the climate impacts of biofuels."). Furthermore, even if BECCS were net zero or negative in the relevant next couple of decades, which it is not, large-scale biodiversity development requires vast land-use changes, which may have significant implications for food security and biodiversity. National Academies of Sciences, Engineering, and Medicine, Negative Emissions Technologies and Reliable Sequestration: A Research Agenda,10 (2019) ("Because food demand is expected to double by mid-century, repurposing a significant amount of current agricultural land to produce feedstocks for BECCS or for afforestation/reforestation might have a significant effect on food availability and food prices, with far-reaching effects on national security and biodiversity."). The IPCC Special Report on Climate Change and Land warns that high implementation of BECCS (11.3 GtCO2 yr-1 in 2050) could increase the population at risk of hunger by	Noted. No action demanded, and this is obviously not the section to disucss the downsides of BECCS. Thanks for making the effort of copying and pasting the same/similar comment wherever BECCS is mentioned in this report	Gabrielle Dreyfus	Institute for Governance & Sustainable Development	United States of America
46243	105	29	105	34	The aspect of "the prospect of CDR obstructing emission reduction efforts" should clearly be given more consideration in this Chapter. Currently it sounds like a vague idea, but based on the findings of McLaren, D. 2020 (Quantifying the potential scale of mitigation deterrence from greenhouse gas removal techniques. Climatic Change 162, 2411–2428, 2020) - an omitted, but important reference - the magnitude of such obstruction could be significant, even up to the magnitude of typical scales of the intended cumulative negative emissions through CDR. Also, given the potential magnitude, it seems appropriate to at least briefly mention the channels of "mitigation deterrence".	Rejected. This section deals with CDR governance and policymaking, stating explicitly that it doesn't deal with merely conceptual literature (incl. paper simply criticizing IAMs). Such literature is mentioned in the opening part of section 12.3 (including two papers deploying/explaning the concept of "mitigation deterrence"), and in section 3.2. While such deterrence might exist in climate policymaking (although it remains unclear whether the literature really is about "mitigation deterrence" or "emissions reductions deterrence"), it has been impossible yet to sufficiently quantify such an effect, including in the suggested paper.	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
65495	105	31	105	33	Could you expand on the 'land rights' comment? For example, a recent review by Creutzig et al., 2021 (https://doi.org/10.1111/gcbb.12798) find that the SR1.5 envisaged levels of BECCS could cause enormous amount of social dislocation. They refer to literature in which prior "land colonization had led to the dispossessing rural and forest communities and pushing them into low -wage job dependency, migration, or the deadly combination of landlessness and joblessness" (Young 1990)	Taken into account. We added more literature (in this section, but also in the concerns listed in the beginning of 12.3) but did not expand on content, since this is highly context-dependent	Albertine Pegrum-Haram	European Climate Foundation	United Kingdom (of Great Britain and Northern Ireland)
46245	105	37	106	39	CDR techniques are addressed here in a purely abstract manner. We kindly ask the authors to rewrite this in order to make clear what specific techniques are referred to with the individual statements. RATIONALE: The text in its present form suggests that underlying technology related problems regarding accounting and MRV will be solvable through research. This conclusion is very questionable in two ways. First, R&D results generally cannot be predicted and second, with regard to underground storage in CCS projects, measurement accuracy is limited by permanent physical restraints (Ivandic et al., 2015 and NETL, 2017a). Furthermore, technical demonstration does not necessarily and not always lead to immediate results. Leakages from underground storages can occur decades after injection (geological processes are usually very slow) and thus the sought and needed experience is not readily achievable (Pawar et al. 2015, NETL, 2017b). This has to be considered and clearly stated when addressing decision makers and when seeking public acceptance. If CCS is considered on a Gigaton scale, one has to keep in mind that it will not be possible to carefully select and monitor all of the needed sites. --- Ivandic, M. , Juhlin, C. , Lüth, S., Bergmann, P., Kashubin, A., Sopher, D., Ivanova, A., Baumann, G. Henninges, J., 2015, Geophysical monitoring at the Ketzin pilot site for CO2 storage: new insights into the plume evolution Int. J. Greenh. Gas Control, 32, pp. 90-105. NETL – National Energy Technology Laboratory, 2017a, Best Practices: Monitoring, Verification, and Accounting (MVA) for Geologic Storage Projects, Report DOE/NETL-2017/1847. Pawar, R.J., Bromhal, G.S., Carey, J.W., Foxall, W., Korre, A., Ringrose, P.S., Tucker, O., Watson, M.N. White, J.A., 2015, Recent advances in risk assessment and risk management of geologic CO2 storage, International Journal of Greenhouse Gas Control 40, pp. 292–311. NETL – National Energy Technology Laboratory, 2017b, Best Practices: Risk Management and Simulation for Geologic Storage Projects, Report DOE/NETL-2017/1846.	Taken into account. We expanded on issues regarding the permanence of carbon storage and how this is related to different CDR methods (see also cross-chapter box on CDR), including MRV, accounting and liablitly. This refers to all CDR methods and eventual reservoirs. We included literature on slow-moving deployment of CCS (incl. social science literature), but did not expand on storage capacities or permanence, issues dealt with in chapter 6 , and not seen as a major concern	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
65497	105	38	105	41	Can you give some examples of corporate actors who are shifting the debate? For example, oil and gas companies like Shell, who are currently planning that "nature based solution" will offset 120 million tonnes of (unspecified if CO2eq, or C - likely CO2) per year by 2030.	Taken into account. We prefer not to name corporate actors explicitly in the report, but a added an article (Joppa et al., 2021) describing the practices of two such companies that try to shape the market for CDR methods with comparatively long storages times	Albertine Pegrum-Haram	European Climate Foundation	United Kingdom (of Great Britain and Northern Ireland)
73927	105	41			The work 'Schenuit et al.' is under submission.	taken into account - it indeed was under submission at the time of SOD, now published	Raehyun KIM	National Institute of Forest Science	Republic of Korea
46247	105	46	106	8	Please rewrite the whole paragraph in a policy-neutral way, removing all the recommendations ("should", "needs to") that are not in line with the IPCC's mandate. Please note that the SR1.5 showed pathways without technological CDR even for 1.5°C, hence the framing of large-scale CDR to be not avoidable does not seem justified.	Taken into account. Argument clarified, consistent with the Cross-Chapter Boxes on CDR (ch12) and Net-Zero (ch3). If a country sets a net-zero target (like many countries already did), then this automatically implies CDR (otherwise, target would not be 'net' zero emissions, but simply zero emissions). This does not necessarily imply large-scale CDR, since it could also be achieved with a low level of residual emissions	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
46249	105	46	106	8	Please add to this paragraph, possibly after "... Geden 2019)" in line 2, an assessment on regulations of CDR techniques (in general, for each individual project, and taking into account the full life cycle) regarding the provision of evidence on their reliable effectiveness to reduce the atmospheric CO2 concentration."	Noted. No change made. The suggested addition reads like a clarification of the last point ("in which ways"), which would be policy prescriptive in the here suggested formulation, since it would go beyond the (LCA) requirements in place for most emissions reduction measures. Comment also seems to refer to global net negative emissions ("reduce atmospheric CO2 concentrations"), whereas the argument is now more clearly based on national targets	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
80221	105	46	106	2	The "core governance question" identified in this sentence is both untrue and does not accurately reflect the cited literature. Nor is the negated core governance concern of "whether CDR should be mobilized or not" supported by the cited literature. Neither paper determinitively claims that the scaled deployment of CDR is a foregone conclusion, or that it is morally, ethically, or politically permissible or necessary. Instead, both papers central claim relates to the immaturity and uncertainty of diverse CDR approaches - namely, that they are nowhere near ready and have none of the social or economic momentum needed to achieve scale or impact. The core governance issue, according to the cited papers, is therefore to enable "rapid learning" about the potential of the portfolio of possible CDR approaches, while acting aggressively to limit dependence on technologies with uncertain potentials and environmental side-effects.	Taken into account. Argument clarified, consistent with the Cross-Chapter Boxes on CDR (ch12) and Net-Zero (ch3). If a country sets a net-zero target (like many countries already did), then this automatically implies CDR (otherwise, target would not be 'net' zero emissions, but simply zero emissions). This does not necessarily imply large-scale CDR, since it could also be achieved with a low level of residual emissions	Kelly Wanser	SilverLining	United States of America
22291	106	1	106	1	The wording "should be mobilised or not," might be misleading : in democratic governance the core question is whether a democratic choice can achieved. There are attempts at modelling alternative pathways, including changes in lifestyle as mentioned in chapter 3 (e.g. p. 33). At this stage these pathways are as realistic as a full-fledge deployment of technological CDR.	Taken into account. Argument clarified, consistent with the Cross-Chapter Boxes on CDR (ch12) and Net-Zero (ch3). If a country sets a net-zero target (like many countries already did), then this automatically implies CDR (otherwise, target would not be 'net' zero emissions, but simply zero emissions). This does not necessarily imply large-scale CDR, since it could also be achieved with a low level of residual emissions. And, as clarified explicitly now in the text, if policymakers or voters do prefer not to explore CDR or specific CDR methods, then this does not devalue the core argument: to fulfil a "net" zero target, CDR is needed, to counterbalance residual emissions	Government of France	Ministère de la Transition écologique et solidaire	France
22293	106	5	106	6	"CDR...deployment": please consider replacing "governance" by "policy", as the statement might appear normative otherwise.	Taken into account, sentence changed (from "governance should" to "governance and policymaking are expected to"	Government of France	Ministère de la Transition écologique et solidaire	France
73929	106	8			There is a difference between 'von Hedemann (in the in-text citation)' and 'vonHedemann (in the References)'.	taken into account - change made in text	Raehyun KIM	National Institute of Forest Science	Republic of Korea
58113	106	9	106	15	The authors discuss the importance of polycentric governance. One important area that is not mentioned is that regional policies to mitigate climate change can have leakage (this is mentioned in Section 12.7.3), when a policy restriction on emissions in one region leads to an increase in emissions in a neighboring region, for instance a regional cap and trade system such as RGGI in the U.S. (Fowlie, Meredith L. 2009. Incomplete environmental regulation, imperfect competition, and emissions leakage. American Economic Journal: Economic Policy 1 (2): 72-112; and Fischer, Carolyn, and Alan K. Fox. 2012. Comparing policies to combat emissions leakage: Border carbon adjustments versus rebates. Journal of Environmental Economics and Management 64 (2): 199-216.).	noted. concept of polycentric governnace not explicitly applied anymore. Leakage concerns being dealt with in section 12.6	Government of United State	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
80223	106	9	106	15	Suggested Add: "A similar governance view applies to SRM. Given the severity of the climate problem and the imperatives for better information, governance of non-climate-impacting research (e.g., models, observations, and small-scale experiments) should be designed to promote progress, leveraging existing frameworks for oversight and assessment. Proven models for assessment may promote rigor, increase confidence, and lay a strong foundation for governance of climate-impacting activities. New mechanisms that introduce non-scientific procedures should be treated with caution. In an environment where there are no existing formal sources of funding and regulatory risks to research are perceived, there is a serious risk that programs will not develop. While some have begun to lay out options and applications of existing laws and frameworks to regulate potential SRM measures (Biniaz & Bodansky 2020; Carlin & James 2018), a comprehensive review of existing laws and protocols should be undertaken to provide a clear picture of the regulatory and governance landscape. Where successful models for experimental oversight or research assessment exist, they should be closely reviewed for applicability and use. New mechanisms that require communications, legal, or other resources not commonly available to researchers should be avoided in favor of existing structures and enabling technologies for open science. Governance initiatives and civil society organizations should consider potential climate intervention in the context of evolving climate risks, with the aim to minimize the combined risks of the two. Rapid generation of information should be promoted in support of informed dialogue with the public." References: Sources: for an analysis of governance frameworks that may govern SRM measures, see • Biniaz, S., & Bodansky, D. (2020). Solar Climate Intervention: Options for International Assessment and Decision-Making. SilverLining and C2ES. https://www.c2es.org/site/assets/uploads/2020/07/solar-climate-intervention-options-for-international-assessment-and-decision-making.pdf • Carlin, N. F., & James, R. A. (2018). Pratt's Energy Law Report: Geoengineering Research under U.S. Law. Pratt's Energy Law Report, 18(3), 67–75.	rejected - section 12.3 is about CDR, not SRM, sub-section therefore on CDR governance only. SRM governance is dealt with in chapter 14 (section 14.5.x)	Kelly Wanser	SilverLining	United States of America
46251	106	13	106	14	Please replace "Ocean Iron Fertilization" by "Ocean Fertilization and the sequestration of Carbon Dioxide Streams in sub-seabed geological formations". Explanation: the London Protocol regulates not only Ocean Iron Fertilization. Annex 4 lists all Ocean Fertilization activities. Furthermore, London Protocol has also regulated the sequestration of Carbon Dioxide Streams. See International Maritime Organization, https://www.imo.org/en/KnowledgeCentre/IndexofIMOResolutions/Pages/LDC-LC-LP.aspx	Rejected. This paragraph ist not about international agreements and their coverage, but about relevant issues for CDR governance and policymaking. Conceptually, sub-seabed storage is equally relevant for CCS applied to fossil fuel use (power, industry, hydrogen) and empirically the sole use case so far, incl. for countries that sought exemption from the initial LC/LP regulation that prohibited CO2 export for sub-seabed storage. LP/LC is treated in more detail in Section 14.4.5, CO2 storage in chapter 6	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
46253	106	15	106	15	Please add after "Chapter 14):": Parties to London Protocol intentionally allowed deployment activities with regard to CO2 sequestration, whereas a prohibition for deployment activities in the field of ocean fertilization was agreed upon."	Rejected. This paragraph ist not about international agreements and their coverage, but about relevant issues for CDR governance and policymaking. Conceptually, sub-seabed storage is equally relevant for CCS applied to fossil fuel use (power, industry, hydrogen) and empirically the sole use case so far, incl. for countries that sought exemption from the initial LC/LP regulation that prohibited CO2 export for sub-seabed storage. LP/LC is treated in more detail in Section 14.4.5, CO2 storage in chapter 6	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
46255	106	17	106	17	Please delete: "To accelerate CDR, a political commitment to formal integration". Please reformulate the whole section and indicate that proposals are stated, now the recommendations are too policy prescriptive. If there will be an emission overshoot, ecosystem based approaches are an option as well, hence there is no necessity from a scientific perspective for those proposals.	Taken into account. Argument clarified, consistent with the Cross-Chapter Boxes on CDR (ch12) and Net-Zero (ch3). If a country sets a net-zero target (like many countries already did), then this automatically implies CDR (otherwise, target would not be 'net' zero emissions, but simply zero emissions). This does not necessarily imply large-scale CDR, since it could also be achieved with a low level of residual emissions. And, as clarified explicitly now in the text, if policymakers or voters do prefer not to explore CDR or specific CDR methods, then this does not devalue the core argument: to fulfil a "net" zero target, CDR is needed, to counterbalance residual emissions. This line of argument does not imply emissions overshoot on a global scale, nor does it indicate the use of specific CDR methods or clusters (biological/geochemical/chemical).	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
46257	106	18	106	18	Replace "is needed" by "would be instrumental". Explanation: As it is written, that it is needed to accelerate CDR. This would be a normative decision far beyond the mandate of IPCC.	Taken into account. Argument clarified, sentence changed, now applying the formal integration to specific proposals (accelerating RD&D and incentivising deployment), avoiding "need" (using "required" instead) and giving more reasons why this is the case (adding substantially on MRV and accounting, which are existing frameworks that need to be expanded)	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
46259	106	20	106	20	After "mechanisms." please insert: "Documenting emission reduction measures and contributions by CDR separately could be beneficial to firstly avoid "mitigation deterrence" in the sense, that emission reduction efforts are reduced, and secondly to be able to document the achievement on emission reductions." See also McLaren et al. 2019: Beyond 'Net-Zero': A case for separate targets for emissions reduction and negative emissions. https://doi.org/10.3389/fclim.2019.00004.	Taken into account, sentence changed to better highlight the reasoning for seperate targets ("To avoid that CDR is misperceived as a substitute for deep emissions reductions, the prioritisation of emissions cuts can be signalled and achieved with differentiated target setting for reductions and removals"): "Mitigation deterrence" not explicitly mentioned, since there are several overlapping concepts using the same basic arguments ("mitigation obstruction", "moral hazard" etc.)	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
58115	106	26	106	32	This reference to markets indicates a very limited role for "niche markets" and "voluntary markets". Voluntary markets refers to what is called a competitive market in economics. If so, the role of markets is understated. Market failures such as pollution are well studied in economics and market mechanisms such as cap and trade and taxes can provide powerful incentives to address GHG emissions and change incentives for consumer and producer behavior. The policies discussed in this section, whether market based or regulatory, will largely if not entirely be enforced through markets. More discussion of the interaction of policies and markets is needed.	Taken into account, paragraph expanded. "Voluntary markets" here means that companies buy CDR products even without being forced to do so (by regulation, which would create "mandatory or compliance carbon markets"). We added on the role of impact investors and philantropy in the early phase of CDR RD&D, but without explicitly naming companies or philantropic organisations (examples to be found in the literature we refer to)	Government of United State	U.S. Department of State	United States of America
12097	106	33	106	33	Suggest an amendment to reflect that not only is public awareness of CDR generally very low, but awareness of the need to CDR is very low (need as described in p105 lines 19 to 23).	Taken into account, sentence expanded ("and its role in national net-zero emissions strategies"	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
28349	106	33	106	39	Section 12.7.1, page 12-106, from line 33 – one of the most important findings with respect to governance of CDR and public perception is that governance itself can change the way people perceive the technologies themselves, see Bellamy et al., 2019 https://www.nature.com/articles/s41467-019-08592-5 In other words, public support for CDR is inextricably linked to attitudes towards the policies through which it is incentivised.	Taken into account, sentence expanded ("the policy instruments chosen to support CDR")	Rob Bellamy	University of Manchester	United Kingdom (of Great Britain and Northern Ireland)
51819	106	40	109	10	Traditional governance systems have evolved to minimize overlap and duplication. How is the risk addressed that introducing a food systems approach, which cuts through several of the existing structures, adds additional potentially contradictory layers while adding duplications and overlaps? This should be discussed in a chapter on food systems.	**Rejected**. Beyond scope of this section.	Florin Vladu	UNFCCC Secretariat	Germany
63191	107	11	107	29	The food-energy-water nexus faces many operational challenges to adoption across local and national scales. Coordination of food, energy, water and climate targets across the global Sustainable Development Goals, as well as across national and sub-national policies, is needed to support complementary progress on climate, food, energy and water sustainability. (Sklarew D. and J. Sklarew. 2018. Integrated water-energy policy for sustainable development. Foresight and STI Governance 12(4): 10-19. doi: 10.17323/2500-2597.2018.4.10.1)	**Noted**.	Jennifer Sklarew	George Mason University	United States of America
51815	107	14	107	14	"reforestation can result in a reduction of less greenhouse gas emissions": Should be either "reduction" or "less", but not both.	**Accepted.** Sentence modified	Florin Vladu	UNFCCC Secretariat	Germany
58117	107	14	107	14	"reduction of less greenhouse gas emissions" should be "reduction of greenhouse gas emissions"	**Accepted.** Sentence modified	Government of United State	U.S. Department of State	United States of America
70623	107	14	107	14	please rephrase	**Accepted.** Sentence modified	Philippe Tulkens	European Union (EU) - DG Research & Innovation	Belgium
58119	107	15	107	16	The text references national food self-sufficiency policies as beneficial for GHG emissions, but fails to acknowledge that many foods that consumers prefer are grown in climates and countries outside their own. It is well known that trade can make everyone better off, improve the variety of goods and lower costs for consumers, and increase prices received for producers. This statement does not discuss the costs to society's welfare of such a policy.	**Accepted.** Sentence modified to neutral formuilation "national and local food self-sufficiency policies may also have GHG impacts "	Government of United State	U.S. Department of State	United States of America
86811	107	15			Please remove the reference to shifts in diets away from meat consumption in relation to GHG impacts.	**Rejected.** Sentence has been modified to mention an GHG impact without indicating the direction of change.	Government of Argentina	Ministry of Environment and Sustainable development of Argentina	Argentina
86809	107	46	108	2	It is important to clarify that private standards and certification schemes shall be developed in a transparent manner and be based on sound scientific evidence on their environmental benefits.	**Partly accepted**. Sentence extended to included 'sound scientific evidence' basis.	Government of Argentina	Ministry of Environment and Sustainable development of Argentina	Argentina
51817	108	2	108	3	Unclear where the conclusion is coming from, given that the UN Food Systems Summit has not yet taken place.	**Noted.** UNFSS has now taken place. Sentence has been slightly modified	Florin Vladu	UNFCCC Secretariat	Germany
10827	108	7	108	14	The reader would evidently like to know what was wrong with the initial food system. Was the foor not tasty? Not healthy? Not safe? Not Finnish enough? Not produced sustainably? Not produced ethically (whatever that means)? In the absence of such knowledge one cannot expect the reader to understand and appreciate the building blocks of the Finnish strategy. Things do not improve much through the box. For example "To enable a shift in individual behaviours, the Finnish government use educational and informative instruments to shape responsible food behaviour" (lines 22-23) has no meaning unless one gets some information about what was wrong in individual behaviours, what was deemed not responsible food behaviour; and so on.	taken into account - now initial problem structure more explicitly spelled out in both cases	Philippe Waldteufel	CNRS	France
58121	108	22	108	22	"use" should be "uses"	accepted - thanks	Government of United State	U.S. Department of State	United States of America
58123	109	2	109	2	MRV is not defined.	accepted - now spelled out (although MRV used before in chapter)	Government of United State	U.S. Department of State	United States of America
58125	109	2	109	3	Use of double negative is confusing: "are atypical for the EU and not only for Finland"	accepted - got rid of the double negative	Government of United State	U.S. Department of State	United States of America
51821	109	17	109	17	"ensuring additionality" is not specific for land-based mitigation, but central to all mitigation that receives climate finance of any kind. As such, this doesn't belong into the list.	Noted. While we agree that additionality is relevant beyond land-based mitigation, we think it is appropriate to mention it here, especially as it raises specific challenges for land-based mitigation.	Florin Vladu	UNFCCC Secretariat	Germany
51823	109	46	109	47	A "common accounting framework" would be required for all mitigation efforts that should be compared or comparable. This is in on way specific for land-based mitigation.	Taken into account. Not included in text on land-based mitigation anymore. MRV/accounting framework now only discussed for CDR, with explicit reference to IPCC guidance for UNFCCC inventories	Florin Vladu	UNFCCC Secretariat	Germany

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
12099	110	1	111	48	It is suggested the text re MRV is expanded to note that CDR MRV will require a global accounting system (Honegger, 2020) and that, given the range of approaches to CDR and the variation with which they remove and store carbon, and the challenges associated with permanency and leakage, any future MRV will have to function in the context of considerable uncertainty (Honegger, 2020). This uncertainty is demonstrated, for example, in the challenges of monitoring, reporting and verifying gas fluxes across many techniques that are, simultaneously, a sink for and source of GHG (Welch et al., 2019). It is then, unclear how the international community may resolve the environmental, policy and research challenges that remain for MRV, and whether and how this might be done within the context of existing frameworks (Florin, 2020). The polycentric governance framework makes these points, perhaps, difficult to find a home in the text. However, there are essential if progress toward Paris Agreement goals are to be tracked, and achieved. REFERENCES HONEGGER, M., MICHAELOWA, A. & ROY, J. 2020. Potential implications of carbon dioxide removal for the sustainable development goals. Climate Policy, 1-21.HONEGGER, M. 2020 'Addressing risks and trade-offs in governance in Florin, M.-V. (Ed.), International Governance of Climate Engineering. Information for policymakers (2020), Chapter 3 Lausanne: EPFL International Risk Governance Center (IRGC).	Taken into account. We expanded considerably on MRV and accounting, with explicit reference to IPCC guidance for UNFCCC inventories. We also added on issues like long-term liabilities	Paul Rouse	Carnegie Climate Governance Initiative (C2G) - The Carnegie Council for Ethics and International Affairs	United Kingdom (of Great Britain and Northern Ireland)
51825	110	8	110	9	Given that it has proven near-impossible to reconcile project-based accounting and national reporting in GHG inventories, e.g. reaching consistent estimates, it must be questioned whether the statement makes sense in the current context. The gains from voluntary markets for reporting of national efforts and GHGIs have arguably been very limited. What has been a game changer is cheap or free high-resolution satellite data and related analysis software, largely automatized with machine learning algorithms for imagery interpretation. This should be mentioned in this context, while the voluntary markets reference for methodologies that measure forest carbon stock changes at scale is at least questionable.	Noted. This section has been substantially reduced to minimise overlap between chapters. Governance of land-based mitigation, including this passage, has been deleted.	Florin Vladu	UNFCCC Secretariat	Germany
58127	110	11	110	11	It is not clear what the phrase "marker conversion" means.	Noted. This section has been substantially reduced to minimise overlap between chapters. Governance of land-based mitigation, including the passage referring to "market conversion", has been deleted.	Government of United State	U.S. Department of State	United States of America
51827	110	18	110	20	The key for REDD+ to address leakage in a country is the national implementation. That makes REDD+ unique. There is arguably a risk of international leakage. However, this would probably best be addressed through promoting inclusivity, aso that all developing countries with significant forests implement REDD+, including HFLD countries, so that such international leakage is immediately detected.	Noted. This section has been substantially reduced to minimise overlap between chapters. Governance of land-based mitigation, including this passage, has been deleted.	Florin Vladu	UNFCCC Secretariat	Germany
24933	110	22	110	24	With regard to the sentence "For example, if forest reference levels in the EU LULUCF Regulation incentivise Member States to constrain harvests to increase forest carbon sinks, modelling indicates considerable leakage to the rest of the world (Kallio et al. 2018)", I suggest that either the full story is told (what is the FRL, and what is its aim) or the message risks to me misleading. This is because, as expained here https://www.sciencedirect.com/science/article/abs/pii/S1389934118302661, "results by Kallio et al. may be of general interest in analysing the impact of setting binding limits on harvest, but it should not be considered as an assessment of the economic impacts of implementing FRLs (because affected by some misunderstandings of what FRLs are)". I would suggest either to: (i) delete the sentence; or (ii) change along this line "For example, if forest reference levels in the EU LULUCF Regulation - which are aimed at reflecting the carbon impact of management choices (Grassi et al. 2018) - incentivise EU countries to constrain harvest to increase forest carbon sinks, a potential risk of leakage to the rest of the world exists (Kallio et al. 2018)". REF. Grassi et al. 2018 https://cbmjournal.biomedcentral.com/articles/10.1186/s13021-018-0096-2	Noted. This section has been substantially reduced to minimise overlap between chapters. Governance of land-based mitigation, including this passage, has been deleted.	Giacomo Grassi	Joint Research Centre, European Commission	Italy
58129	110	44	110	47	Authors indicate that there is a trade-off between renewable energy production and food production. However, in Section12.5, there is a discussion of the co-location of micro solar (included here) and commercial scale wind energy, which is not mentioned here.	Accepted. Mention of co-location with wind power has been added.	Government of United State	U.S. Department of State	United States of America
61889	110	44	110	47	"Strategic spatial planning is needed more generally to address trade-offs between using land for renewable energy and food: for example, agriculture and solar photovoltaics can be co-located (Barron-Gafford et al. 2019). Integrative spatial planning can integrate renewable energy with not just agriculture, but mobility and housing (Hurlbert et al. 2019)." As an energy source with by far the smallest land use of all non-fossil methods, nuclear energy could alleviate the land-use issues of which the renewables suffer from. This should be mentioned and discussed as an option, given that we also face a biodiversity crisis and land-use is becoming more and more critical matter.	Noted. The small land footprint of nuclear is noted in 12.5.2 and 12.5.3.	Rauli Partanen	Think Atom	Finland
65933	110	44	110	47	"Strategic spatial planning is needed more generally to address trade-offs between using land for renewable energy and food: for example, agriculture and solar photovoltaics can be co-located (Barron-Gafford et al. 2019). Integrative spatial planning can integrate renewable energy with not just agriculture, but mobility and housing (Hurlbert et al. 2019)." How about nuclear energy? As an energy source with the smallest land use of all non-fossil sources, could it alleviate the land-use issues of which the renewables appear to suffer from? If so, i think it would be illustrative and fair to mention that in the draft as well? Revise accordingly.	Noted. The small land footprint of nuclear is noted in 12.5.2 and 12.5.3.	Eero Hirvijoki	Aalto University	Finland
58131	111	43	111	44	The reference to voluntary agreements does not include a discussion of the fact that these agreements are not binding. Countries that are unable or unwilling to meet their climate mitigation commitments have simply not honored agreements.	Taken into account - moved from text	Government of United State	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
9377	112	4	112	21	Although this is a rather short FAQ (especially compared to the Working Group I and II FAQs), I think this is a good example of the style, language and level of detail that authors could aim for. The last paragraph could probably expand on potential side effects and trade-offs, costs and efficiency or the current knowledge about the usefulness of these options, e.g. from model calculations or tests.	Rejected: This FAQ is about how CDR options removed CO2 from the atmosphere. Covering potential side effects and trade-offs, costs and efficiency would make it too long for a FAQ - dealt with in detail in the chapter	Maike Nicolai	Helmholtz Centre Geesthacht	Germany
63271	112	4	112	21	FAQ 12.1: In general, this FAQ is primarily descriptive. It would be of more value if it could convey the results of WGIII's assessment of various CDR options in terms of potential capacity to remove CO2 from the atmosphere, associated costs, and potential environmental side effects, if relevant.	Rejected: This FAQ is about how CDR options removed CO2 from the atmosphere. Covering potential side effects and trade-offs, costs and efficiency would make it too long for a FAQ - dealt with in detail in the chapter	Government of Canada	Environment and Climate Change Canada	Canada
65499	112	4	112	21	This is a great inclusion and will be very helpful to policy/communications audiences. However I think more could be done here to draw in the nuances discussed in the previous sections. For example, when talking about DACCS you could say "it has X potential co-benefits, X risks, and is in X stages of development". Policy makers/communicators will appreciate the technical explanation, but the next natural question is what technology to aim at. For this it might be worth including a discussion on the multi-method resilience, as outlined in the chapter, with no one solution fits-all approach. Alternatively singpost to the table in the text (12.6) where these points are outlined.	Rejected: This FAQ is about how CDR options removed CO2 from the atmosphere. Covering potential side effects and trade-offs, costs and efficiency would make it too long for a FAQ - dealt with in detail in the chapter	Albertine Pegrum-Haram	European Climate Foundation	United Kingdom (of Great Britain and Northern Ireland)
22295	112	6	112	7	We recommand to put more caution to this statement given the uncertainty. It invits to put faith in technologies in there infancy, with high costs so far and unassessed adverse impacts.	Rejected: All scenarios that limit warming to 1.5°C -2°C require some quantity of CDR	Government of France	Ministère de la Transition écologique et solidaire	France
63265	112	6	112	6	FAQ 12.1: As written, this text implies that the international commitment is to limit global warming to between 1.5C and 2C. That is not the case. The Paris Agreement target is to hold the increase in global warming to well below 2C.	Accepted. Working changed.	Government of Canada	Environment and Climate Change Canada	Canada
46503	112	9	112	11	FAQ 12.1: aren't there also co-benefits of biological methods? Please give a more balanced evaluation of pros and cons of biological vs new technological approaches.	Accepted: Wording changed to "While these practices, if implemented well, can provide a range of co-benefits, given the expected scale of deployment required to limit warming to well below 2°C, they could result in adverse side effects such as biodiversity loss or food price increases"	Government of Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety International Climate Policy	Germany
63267	112	10	112	10	FAQ 12.1: The side effects here seem specific to land-based CDR options. Suggest rewording "Given an expected scale of deployment" to something like "Given that many modelled emission pathways to limit global warming to well below 2C currently include large scale deployment of land-based CDR...."	Accepted: Wording changed to "While these practices, if implemented well, can provide a range of co-benefits, given the expected scale of deployment required to limit warming to well below 2°C, they could result in adverse side effects such as biodiversity loss or food price increases"	Government of Canada	Environment and Climate Change Canada	Canada
63269	112	13	112	14	FAQ 12.1: Suggest these lines about the potential reversal of biological CDR methods be moved up to follow the setence about side effects from biological approaches on lines 10-11. In addition, the phrase "more vulnerable to reversal" requires explanation, especially in an FAQ intended for general audiences.	Accpepted: Text moved as suggested.	Government of Canada	Environment and Climate Change Canada	Canada
9379	112	23	112	31	Some examples might be useful here to illustrate the different aspects. You could perhaps also consider a reference to the SDGs as done across this report. If no other FAQ addresses linkages between mitigation and adaptation, this could also be done here.	Accepted. Two examples have been added. The link to adaptation has also been suggested, although there is not the space available to do a full description of the links between mitigation and adaptation	Maike Nicolai	Helmholtz Centre Geesthacht	Germany
123	112	32	113	8	FAQ 12.3 is related to the animal vs. plant source food discussion in the preceding comment. However, a) it is insufficiently substantiated in the chapter, and b) it calls for a holistic approach, which is overly simplified and implicit, if not largely lacking.	Accepted. The term 'holistic appraoch' has been replaced with 'food system approach' that reflects better the content of the FAQ and the evidence assessed.	Harry Aiking	Vrije Universiteit, Institute for Environmental Studies	Netherlands
70021	125	8	125	8	Add: Córdova, R., Hogarth, N., Kanninen, M. 2019. Mountain farming systems' exposure and sensitivity to climate change and variability: Agroforestry and conventional agriculture systems compared in Ecuador's indigenous territory of Kayambi people. Sustainability 11(9) 2623. https://doi.org/10.3390/su11092623.	Rejected. Not relevant to the excutive summary	Markku Kanninen	University of Helsinki	Finland
25009	147				In the "Reduce food loss and waste" row and column "Simplicity/Context":Replace: "Reducing food loss/waste can be achieved through improved harvesting techniques, on-farm storage, infrastructure, and packaging."With: "Reducing food loss/waste can be achieved through improved harvesting techniques, on-farm storage and infrastructure, improved packaging, regulation of unfair trading practices, relaxation of cosmetic standards, mandatory food waste reporting and targets, reforming best before dates and portion sizes, and consumer education."	Rejected. Not relevant to the excutive summary	Carina Millstone	Feedback Global	United Kingdom (of Great Britain and Northern Ireland)
85607	151	1	151	39	First author name is missing.	Noted. References style was changed	San Win	Environmental Conservation Department, Ministry of Natural Resources and Environmental Conservation	Myanmar
18501	181	1	181	1	Shouldn't energy requirements be mentioned in this table? Probably as a geophysical resource, or as a constraint on technological scalability. Table 1	Noted. A clarification has been added to the table in the supplementary material.	Government of United Kingd	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
18503	181	1	181	1	There are surprisingly few references in the last column, although I appreciate that many of the references are reviews summarising a large body of literature. It would be helpful to explain this, but even so, I think some of the reviews are not mentioned in as many rows as they could be. Table 1.	Noted. More references have been added.	Government of United Kingd	Department for Business, Energy & Industrial Strategy	United Kingdom (of Great Britain and Northern Ireland)
28347	181	13	182	1	SM 12.B Table 1 – Bellamy et al. (2016) is missing from the public acceptance column regarding DACCS https://journals.sagepub.com/doi/full/10.1177/0963662514548628	Accepted. The suggested reference has been added.	Rob Bellamy	University of Manchester	United Kingdom (of Great Britain and Northern Ireland)
61891	184	1	187	4	In SM 12.C Table 1 & SM 12.C Table 2, the term "renewable energy" is used multiple times yet the term "nuclear energy" does not appear at all. To be more scientifically accurate, relevant from climate mitigation point of view and technology neutral, the term "renewable" should be changed to "low-carbon". "renewable" is a problematic term, as discussed by Harjanne and Korhonen, 2018, https.doi.org/10.1016/j.enpol.2018.12.029.	Accepted: Changed renewable to low carbon	Rauli Partanen	Think Atom	Finland

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
65935	184	1	187	4	In SM 12.C Table 1 & SM 12.C Table 2, the term "renewable energy" is used multiple times yet the term "nuclear energy" does not appear at all. Given that both technologies are low-carbon, scalable, and deployable, why is the emphasis only on renewables? This choice of words is technologically biased and the term "renewable" should be changed to "low-carbon", for every occurrence in the tables.	Accepted: Changed renewable to low carbon	Eero Hirvijoki	Aalto University	Finland
74255	184	8	184	9	In SM 12.C Table 1 (E.) Renewable Energy should be modified to refer to carbon free energy to incorporate nuclear and other non-carbon energy generation.	Accepted: Changed renewable to low carbon	Jeffrey Merrifield	Pillsbury Law Firm	United States of America
74257	185	3	187	4	In SM 12.C Table 2 (VII. Air Pollution) This section should be modified to inlude other carbon free energy options besides renewable energy, such as nuclear, that can be used to provide clean, carbon free energy to replace fossil fuels.	Accepted: Changed renewable to low carbon	Jeffrey Merrifield	Pillsbury Law Firm	United States of America
8161					It is well appreciated that topics like substitution (of fossil fuel-intensive materials through e.g. biomass) and multi-purpose forest management (A/R not only for C sequestration) are finally fully acknowledged in an AR.	Noted.	Joachim Rock	Thuenen-Institute of Forest Ecosystems	Germany
25011					In the “Reduce food loss and waste” row and column “Technological scalability/Context”: Replace: “Improved harvesting techniques, on-farm storage, infrastructure, packaging to keep food fresher for longer, use renewable energy for food product transformation. Efficiency of food processing and transportation.”With: “Improved harvesting techniques, on-farm storage, infrastructure, packaging to keep food fresher for longer, use renewable energy for food product transformation, regulation of unfair trading practices, mandatory food waste reporting and targets for businesses, relaxation of cosmetic standards to reduce product rejections, reforming best before dates and portion sizes, and consumer education. Efficiency of food processing and transportation.”Justification: It is important recognise regulatory solutions to food waste arising in the pre-consumer supply chain – such as unfair trading practices legislation (EU Platform on Food Losses and Food Waste, 2019, p. 10; Sinclair Taylor, Parfitt and Jarosz, 2019) and mandatory food waste reporting and targets (HM Government, 2018; EU Platform on Food Losses and Food Waste, 2019, p. 27; Tesco PLC, 2019). Creative marketing of cosmetically imperfect practices can significantly reduce cosmetic outgrading (Federico, Dewitz and Magdalena, 2017; van Giesen and de Hooge, 2019).	Rejected. These statments were not found in our Chapter.	Carina Millstone	Feedback Global	United Kingdom (of Great Britain and Northern Ireland)
25013					Replace: “All food supply chain stages can contribute to reduction in food loss and waste, where food losses occur at the farm, post-harvest and food processing/wholesale stages, while in the final retail and consumption stages the term food waste is used (see Section 7.4.5.2 HLPE 2014).” With: “All food supply chain stages can contribute to reduction in food loss and waste, where food losses occur at the farm, post-harvest and food processing/wholesale stages due to technical issues such as lack of infrastructure and storage, while the term food waste is used to refer to food wasted due to socio-economic factors at all stages of the supply chain (see Section 7.4.5.2 HLPE 2014).” Justification: There is considerable evidence for the existence of food waste in the supply chain due to overproduction, cosmetic outgrading and unfair trading practices (Gille, 2012; Gunders, 2012; Colbert and Stuart, 2015; Colbert, 2017a, 2017b; Bowman, 2018; Devin and Richards, 2018; Gascón, 2018; Soma, 2018; Johnson et al., 2019; Sinclair Taylor, Parfitt and Jarosz, 2019; Stangherlin, Duarte Ribeiro and Barcellos, 2019; Markou et al., 2020; Messner, Johnson and Richards, 2021). There is a lack of data globally on primary production food waste, and particularly food left unharvested (Stenmarck et al., 2016; Redlingshöfer, Coudurier and Georget, 2017; Hartikainen et al., 2018; Porter et al., 2018) – however, evidence suggests that this is likely to be high in both developed countries (FAO, 2011; Hartikainen, 2017; Redlingshöfer, Coudurier and Georget, 2017; Devin and Richards, 2018; Garcia-Herrero et al., 2018; Hartikainen et al., 2018; Johnson, 2018; Johnson et al., 2018; Porter et al., 2018; WRAP, 2019; Messner, Johnson and Richards, 2021) and developing countries (Clapp, 1994; FAO, 2011; Gille, 2012; Colbert, 2015, 2017a, 2017b; Colbert and Stuart, 2015; Soma, 2018). FAO have previously estimated that 32% of global food waste occurs at agricultural level (distinct from the post-harvest stage, where an additional 23% of food waste occurs) – this is more than any other stage of the supply chain (FAO, 2011) – however, agricultural food waste or “harvest food loss” was excluded from the FAO’s subsequent 2019 report (FAO, 2019). This was because reporting of post-harvest losses is required for the FAO’s Food Loss Index, but measuring and reporting harvest losses through for instance crop cutting surveys is optional (FAO, 2019, p. 11) and in practice no country (to Feedback’s knowledge) has yet reported robust national level data – a global data gap which urgently needs to be filled in light of the considerable evidence from smaller-scale studies and estimates cited above.	**Partly accepted.** While we agree with the analysis provided, we refer here to the definition of HLPE, which explicitly links the differentiation of food loss and waste to the food chain stage and not to its cause. ‘2. This report adopts a food security and nutrition lens and defines food losses and waste (FLW) as “a decrease, at all stages of the food chain from harvest to consumption, in mass, of food that was originally intended for human consumption, regardless of the cause”. For the purpose of terminology, the report makes the distinction between food losses, occurring before consumption level regardless of the cause, and food waste, occurring at consumption level regardless of the cause. It further proposes to define food quality loss or waste (FQLW) which refers to the decrease of a quality attribute of food (nutrition, aspect, etc.), linked to the degradation of the product, at all stages of the food chain from harvest to consumption.’ Therefore, the proposed sentence won’t be correctly reflecting the common definition of the terms. We have addressed the point by adding a sentence, so that it reads now: “Food losses occur at the farm, post-harvest and food processing/wholesale stages of a food supply chain, while in the final retail and consumption stages the term food waste is used (HLPE 2014). Typically, food losses are linked to technical issues such as lack of infrastructure and storage while food waste is often caused by socio-economic and behavioural factors.”	Carina Millstone	Feedback Global	United Kingdom (of Great Britain and Northern Ireland)
58133					The figures and tables in the SOD draft are almost all too blurred to read or follow. Additionally, many are far more complicated than need be -- some to the point of being useless (see, e.g., Figure 12.6 and, to a slightly lesser degree, Figure 12.8).	Accepted. Figure 12.6 required more explicatory text - for which no space is available. Therefore, it has been deleted for the FGD. The text around Figure 12.8 has been changed to improve clarity.	Government of United State	U.S. Department of State	United States of America
58135					Section 12.5.1 should be emulated throughout the chapter with respect to introducing new topics. It lets readers know what will be covered, what will not be covered (and where that material can be found), and what can be expected in terms of results (with an emphasis on GHG mitigation).	Noted. Introductory text added to other sections in chapter explaning scope and providing cross-references.	Government of United State	U.S. Department of State	United States of America
58137					The relationship between AFOLU and the potential of bioenergy to mitigate GHGs is almost tied to nationally specific forest governance and conservation statuses. For nations with poor governance and degrading forest practices, bioenergy is potentially a path towards further land degradation, and potentially the opposite for other nations like the U.S.	Noted. The aspects brought up in this comment are important and covered in Ch7, especially section 7.4 and 7.6	Government of United State	U.S. Department of State	United States of America

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
58139					Quite a substantial portion of the chapter is given to policy actions regarding agriculture and food creation/distribution GHG mitigation. Perhaps a cross-sectoral issue overlooked is the science and policy decisions needed to deal with a reduction in agricultural acreage and afforestation/reforestation efforts. Is afforestation/reforestation focused on lower quality non-agricultural areas with poor tree stocking or regeneration, or is it focused on former agricultural areas of higher quality soil and GHG mitigation potential? It seems that this is an important delimiter of GHG mitigation trajectories.	**Noted**. Mitigation potential of afforestation/reforestation is assessed in Chapter 7. Section 12.4.2.2 addresses the benefit of reducing land use giving the opportunity e.g. for carbon sequestration options. The assessment of the policy options are taking a systemic approach to work on both supply and demand.	Government of United State	U.S. Department of State	United States of America
58141					The use of terms "net zero carbon dioxide" and "net zero greenhouse gases" is inconsistent and ambiguous in Chapter 12. These are different concepts. Chapter 12 authors should follow the example set in the IPCC Special Report on 1.5°C and use definitions in the glossary of that document. This is important because of the UNFCCC objective to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". This implies that net carbon dioxide emissions go to zero (because of the carbon cycle), but not necessarily other greenhouse gases. The easiest fix is to use "net zero carbon dioxide" everywhere in Chapter 12, replacing all occurrences of "net zero" and "net zero greenhouse gases".	Taken into account. There is indeed an important difference between net-zero CO2 and net-zero GHG. In accordance with WG3-wide guidance, we do not apply net-zero uniformely to CO2 (as suggested here) but always make clear whether we talk about net zero CO2 or net zero GHG, to avoid any ambiguity	Government of United State	U.S. Department of State	United States of America
58143					In Section 12.5, there is a lack of reference to the role of markets in allocating goods and how prices will influence and be influenced by changes in GHG.	Noted. These aspects are covered in other chapters, such as 3 and 13.	Government of United State	U.S. Department of State	United States of America
58145					The limited discussion of Figure 12.9 highlights a weakness of Section 12.5. There is no discussion of the transition from the current state of the world, with a reliance on fossil fuels, to the future state of the world that is the focus of the section, with a reliance on renewable fuels. The power densities in the figure indicate that natural gas is the most energy dense fuel, followed by nuclear, then oil, yet there is no discussion of these fuels or the costs that will be involved in transitioning off these fuels. Nor is there a discussion of the land use changes that will be involved in ending the development of these fuels. An acknowledgment that there are cross-sectoral implications of this shift are needed.	Noted. Fossil fuels and nuclear - as well as the cost of transitioning from these - are covered in several other chapters including ch3 and ch4 and sectoral chapters (Ch6-C11). Section 12.5 does not cover the transition per se, but land related impacts, risks and opportunities associated with mitigation options. We do not understand the comment that 12.5 does not discuss land use changes, as this is a central topic in the section.	Government of United State	U.S. Department of State	United States of America
58147					While Annex B notes that the dollar year throughout the report is 2015, the dollar year is not explicitly noted anywhere within the chapter. It would be helpful to have at least one mention of the dollar year in the chapter itself.	Partly accepted. USD2015 is used where possible and now shown in relevant places in the chapter	Government of United State	U.S. Department of State	United States of America
58149					There are large portions of text that have grammatical issues, primarily around subject-verb agreement and missing or incorrect articles.	Noted. Errors will be corrected and grammar will be fixed where noted.	Government of United State	U.S. Department of State	United States of America
58151					Some of the figure titles are too long (e.g., Figure 12.6 and Figure 12.8). Recommend providing short titles and adding the remaining content in the chapter text.	**Accepted.** Figure 12.6 has been deleted due to space limitations in the FDG; Caption of Figure 12.8 has been shortened as explanations are given in the Figure legend already.	Government of United State	U.S. Department of State	United States of America
60507					The role of Carbon Capture and Utilisation, especially the one of CO2 mineralisation as climate mitigation option and enhancer of circular processes for the industry should be cited in Chapter 12 as it is crucial in cross-sectoral perspective e.g. in the context of industrial symbiosis.•Laval et al., 2021, Journal of Cleaner Production, 280, 124327. 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.	Noted - however, Chapter 6 discusses utilization more fully (Section 6.4.2.5 Carbon Dioxide Capture, Utilization, and Storage)and this section focuses on the novel part and emphasizes the capture part. Utilisation is common with other carbon capture technologies (e.g., fossil, bioenergy) and its discussion is restricted here.	Célia Sapart	Université Libre de Bruxelles / CO2 Value Europe	Belgium

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
60517					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. One importantcross-perspective point that is neglected in CHapter 12 is importance of Industrial perspective on the development of technologies as for CCU (Laval et al., 2021). 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	Noted - however, Chapter 6 discusses utilization more fully (Section 6.4.2.5 Carbon Dioxide Capture, Utilization, and Storage)and this section focuses on the novel part and emphasizes the capture part. Utilisation is common with other carbon capture technologies (e.g., fossil, bioenergy) and its discussion is restricted here.	Célia Sapart	Université Libre de Bruxelles / CO2 Value Europe	Belgium
65599					The chapter should acknowledge the importance of the Oceans as a source of carbon sink throughout the text and figures/tables.	Noted: The role of oceans as a carbon sink is noted in the blue carbon section {12.3.2.3}	Mônica M. C. Muelbert	UNIFESP	Brazil
81657					The benefits of restoring existing forests (i.e. restoration) needs to be in a separate section to planting new forests (i.e. afforestation). This is because the management actions and investment (at least in the NZ context) are quite different, restoration tends towards conservation management while afforestation is more commercial forestry. The risks and benefits differ, as do the policy levers, and the financial investment. The money invested in afforestation significantly exceeds the money spent restoring / protecting NZ's existing native forests. The benefits of restoring existing but degraded native forests (e.g. by controlling browsing herbivore pests, controlling weeds and replanting), is it has much lower land requirements for new land than afforestation. Having greater emphasis may help governments formulate policy to aid in restoration management of our existing native forests.	Noted. Chapter 7 considers separately afforestation/reforestation; improved forest management; forest protection. To minimise repetition across the report we discuss these options only briefly here, in 12.5.	Government of New Zealand	Ministry for the Environment	New Zealand

Comment Id	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
83751					The role of Carbon Capture and Utilisation, especially the one of CO2 mineralisation as climate mitigation option and enhancer of circular processes for the industry should be cited in Chapter 12 as it is crucial in cross-sectoral perspective e.g. in the context of industrial symbiosis.•Laval et al., 2021, Journal of Cleaner Production, 280, 124327. 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.	Noted - however, Chapter 6 discusses utilization more fully (Section 6.4.2.5 Carbon Dioxide Capture, Utilization, and Storage)and this section focuses on the novel part and emphasizes the capture part. Utilisation is common with other carbon capture technologies (e.g., fossil, bioenergy) and its discussion is restricted here.	Christian Breyer	LUT University	Finland
83761					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. One importantcross-perspective point that is neglected in CHapter 12 is importance of Industrial perspective on the development of technologies as for CCU (Laval et al., 2021). 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	Noted - however, Chapter 6 discusses utilization more fully (Section 6.4.2.5 Carbon Dioxide Capture, Utilization, and Storage)and this section focuses on the novel part and emphasizes the capture part. Utilisation is common with other carbon capture technologies (e.g., fossil, bioenergy) and its discussion is restricted here.	Christian Breyer	LUT University	Finland