Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
33159	0		9		The summary is extended and excellent	noted	Alam	Edris	Rabdan Acadmey	United Arab Emirates
1917	0				A key trend to be assessed in this report is the trend in coal use w/o CCS and its comparison to the full range of scenarios including RCP 8.5. Coal use exhibits very strong growth in RCP 8.5 and a strong decrease in 1.5 and 2C scenarios. This assessment should provide data that indicates if RCP8.5 remains a realistic pathway which Hausfather and Peters https://www.nature.com/articles/d41586-020-00177-3 argue it does not, and this chapter should consider coal use in the context of the implementation and emissions gap recognizing that SR15 found coal use useful as a metric in differentiating between pathways.	Noted. We already now include some language around this and have developed this further. However, what remains "realistic" will be very different to different people.	Kheshgi	Haroon	ExxonMobil Research and Engineering Company	United States of America
1943	0				Since this chapter is on past trends, suggest not discussing future commitments (the implementation gap is a key topic in Chapter 4) but rather put past trends in the context of the decades of past climate policy.	Accepted, future reduced to minimum necessary	Kheshgi	Haroon	ExxonMobil Research and Engineering Company	United States of America
6901	0				Throughout the whole chapter, it should be made clear whether CO2 refers to the GHG CO2 only, or various GHGs reported as CO2 equivalents. This is sometimes not clear.	Accepted, distinctions made	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
6903	0				In the first part of the chapter CH4 receives quite some attention and different conversion factors for calculating CO2 equivalents are discusse. Afterwards the analyses only focus on CO2 only, although there is also research on CH4, which is not mentioned in the report. The differences between CO2 and CH4 in terms of patterns, economic drivers, size of net-emission imports and exports, difference between production- and consumption-based emissions, etc. deserves more discussion.	Accepted, CH4 discussion extended	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
10291	0				I'm surpirsed that there is no dedicated discussion of the role of air quality as driver for emission reductions and technology change. This deserves a dedicated section because it provides an important factual/observation basis that can then provide a link to relevant discussions in chapters 3, 4 and others (9-11, potentially 17). Similarly, it would be relevant to assess policy initiatives that specifically focus on short-lived climate forcers (e.g. CCAC), but also relevance of e.g. the Kigali Agreement for climate change outcomes and success factors.	Accepted, air quality as driver and related policies included	Reisinger	Andy	NZAGRC	New Zealand
10293	0				The chapter should spell out up-front what regional break-down is used and motivate/justify this break-down. This can be amended in specific sections (i.e. where the literature motivates, or even necessitates, a different break-down. At present, the chapter in many places just uses certain categories but without explaining why it uses those and not others - this potentially raises unnecessary sensitivities, but also is a missed opportunity to demonstrate that and why for the discussion of some issues, certain regional categorisations (especially by income level) are simply necessary to do justice to the scientific literature.	Accepted, regional breakdown and diversions explained.	Reisinger	Andy	NZAGRC	New Zealand
10295	0				The chapter does a good job in providing uncertainty/confidence language in the executive summary, but it doesn't do this in the body of the chapter. It is critical that the chapter demonstrates, in concluding each section, what conclusions it reaches and why, and why it ends up with a specific confidence level. I.e. demonstrate and justify your conclusions within the text - otherwise there is a large gap between the body of the chapter and its executive summary, where the assessment falls out of the sky. Make sure the assessment is done organically within the chapter, concluding each major section/issue.	Accepted, uncertainty and confidence assessments added in sections.	Reisinger	Andy	NZAGRC	New Zealand
10297	0				There is significant overlap with chapter 5 - on balance I would suggest that authors reduce their treatment of behavioural issues and rather import or point to key conclusions arising from chapter 5, and focus more on offering the relevant data/trends that chapter 5 (and others) can and do make use of.	Taken into account. The section has been shortened to avoid many overlaps with chapter 5	Reisinger	Andy	NZAGRC	New Zealand
10299	0				I feel that the chapter in many places is not as clear as it could be to separate correlation and causation. Focusing the assessment more on causation is important (or being clear where a causal analysis simply does not offer any robust results). Specific examples are provided later.	Accepted, distinctions made, causation better explained.	Reisinger	Andy	NZAGRC	New Zealand
10301	0				The discussion of issues related to trade needs to be harmonised. It currently occurs in at least three different places (2.3, 2.4.5, and 2.7). This results in a disjointed, repetitive and in places inconsistent treatment of this very important and sensitive issue.	Accepted, trade discussions harmonized.	Reisinger	Andy	NZAGRC	New Zealand
10303	0				The chapter has enormous potential to provide a whole raft of key figures that illustrate trends and correlations that could be very useful for science communication across a whole range of issues. I would encourage the authors to discuss early on a long-list of figures that deserve dedicated support to make them attractive and accessible and discuss support options with the TSU.	Accepted, figures improved.	Reisinger	Andy	NZAGRC	New Zealand

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
16197	0				Chapter 2 would be greatly improved with a section that focuses on military drivers of climate change. Its absence is an obvious blind-spot that weakens the impact of the report. In addition, the same drivers that work to increase income inequality may be coupled with increasing military GHGeq emissions, so one overall thesis of the chapter could be strengthened by including a treatment of military emissions.	Noted. This would indeed be an interesting analysis, however, there is no reliable literature on this topic	Helman	Daniel	College of Micronesia-FSM	Micronesia, Federated States of
28203	0				This chapter presents overview of rgeional and sectoral trends in emission growth. What the chapter does not do is to combine the regional and sectoral trends. http://www.ppmc-transport.org/wp-content/uploads/2015/08/Analysis-on-National-Transport-Sector-Emissions-1990-2012.pdf gives a regional overview of transport emission growth trends. It is important for policy makers to have this combioned perspective. See also http://www.slocat.net/wp-content/uploads/legacy/slocat_transport-and-climate-change-2018-web.pdf for regional breakdown	Noted. We have not changed the structure as it would go beyond what we can do within our page limit. We have added individual graphs, which combine this information. However, the sector chapters (6-11) are the best places for these kinds of graphs.	Huizenga	Cornie	CESG	Germany
37163	0				an analysis of current trends by fossil fuel source (coal/oil/gas) seems to be missing, which would look into the increasing role of gas in increasing fossil fuel emissions. Section 2.8 does not refer to the role of transition to gas not being consistent with carbon budget, as it only refers to committed aemissions.	Noted. We show trends in fossil CO2 emissions by source. Section 2.8 highlights that carbon commitments of fossil fuel infrastructure are inconsistent with the carbon budgets. In comparison with scenario literature we show that non-electric energy is the bottleneck in the transition - the implication is that gas infrastructure is not and phased out.	Schaeffer	Michiel	Climate Analytics	Netherlands
41039	0				Regarding the use of CO2-eq: As explained quite well in the current draft, the use of CO2eq emission have some problematic aspects related to transparancy, applicability and stabilaty. I can see some effort is made to avoid using this aggregated measure, but I think there is still a potential for avoding this to a lager extent - and thereby achieving enhanced transparency and clarity	Noted. We have worked on this and the box on metrics as well as the appendix on the topic.	Fuglestvedt	Jan	CICERO	Norway
41041	0				In the cases where you talk about GHG (especialy in the first instance) make it clear which gases that are included.	Noted	Fuglestvedt	Jan	CICERO	Norway
41043	0				When you have to use CO2-equivalent emissions - in spite of ambitions and efforts to avoid that - be clear about which GWPs you are using, i.e. from which AR and wich time horizon	Accepted. We make this clear in the text	Fuglestvedt	Jan	CICERO	Norway
41045	0				You use GWPs to calcuclate the contributions to total CO2-eq emission. But the meaning of this total effect is not discussed. This is based on tradition. What is it telling?	We discuss this now in the box on emission metrics	Fuglestvedt	Jan	CICERO	Norway
41047	0				Regarding the use of remaining carbon budgets: Please be consistent with WGI ch5 as well as WGIII ch3. Use of Contributing authors across reports and across chapters may help.	We use the WGI SOD budgets now	Fuglestvedt	Jan	CICERO	Norway
41049	0				If possible, in terms of basis in data and scientific literature, it would be useful with some more attention to the sectors Shipping and Aviation, due to their special role in international climate policies.	Rejected. This is the job of the transport chapter. We are too space-constrained.	Fuglestvedt	Jan	CICERO	Norway
41057	0				Sometimes I wonder - given the approved outline - whether Ch2 is going a bit beyond its scope; e.g. on remaining carbon budgets and transitions needed to stay below temp levels. But - on the other hand, if these topics ar treated in a consitent manner across chapters, these may function as ery useful links between chapters and enhance integration in the WGIII report. Please check consitencey and whether more cooridnation is needed.	Rejected. Unless we put emission trends into context, analysis will be meaningless. I think these are good examples of cross-chapter and cross-WG integration.	Fuglestvedt	Jan	CICERO	Norway
41061	0				The material on committed warming from infra structure is important and relevant. This has a great potential for synthesis with WGI work on committed warming in the climate system. In order to support such a synthesis, documentation and transparencey is important.	Noted - thanks.	Fuglestvedt	Jan	CICERO	Norway
41079	0				I think the draft of Chapter 2 is in good shape. It is has a lot of good material which is well presented	Noted.	Fuglestvedt	Jan	CICERO	Norway
45935	0				Most figures in this chapter relate to countries (with many panels that are instructive but far from providing a compact synthesis), to the World, or to a division of the World in just two parts - OECD vs non-OECD. I would suggest that in developing the final figures, you consider an intermediate division by groups of countries that share similar properties in relation with emission changes (as, for example, AR5 WGIII fig 5.14), and possibly figures that synthesize changes for countries in the same diagram (such as AR5 WGIII fig 5.11).	Accepted, figures revised to the extent data allow.	Marbaix	Philippe	UCLouvain, Belgium	Belgium
18425	1	1	1	1	In the whole chapter, the specific counties name are mentioned very frequently. To avoide some political views, it is better to change the name of the country to the name of region.	Rejected. Statements and data need to refer to countries and regions which they are related to based on the assessed literature source	Shiyan	Chang	Tsinghua University	China

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
27595	1	1	100	70	Chapter 2 doesn't seem to include GHG emissions from land permafrost, ocean floor, ecosystems, soil. I wonder where they are included. I f they aren't yet, I suggest to appoint experts to report these 4 sources of ghg emissions.	Rejected. This is not our mandate in WG3. We include anthropogenic sources by sector and region. These aspects are important, but covered by WG1.	Retelska	Dorota	Independent	Switzerland
30467	1	1	102	1	For the whole list of drivers, diet is not mentioned at all, and meat only twice (and once in the bib). How can this be correct, when the SR1.5C stated that 1/5th of emission reductions could come from diet (ch. 4). Why is diet not included, when it is a powerful consumption, and statistics related to emissions are increasing, what happened?	Taken into account. The text in section 2.6 mentions meat as one of the major contirbutors to household emissions and also as a factor that affects difference in emissions between men and women. Section 2.4 discusses drivers from different perspectives, including socio-eonomic factors but does not go into the details up to the level of diet.	Cook	Lindsey	Quaker United Nations Office / Friends World Committee for Consultation (IPCC Observer)	Germany
9217	1		142		Despite commitments of most countries to reduce emissions, global GHG emissions were the 3 highest in human history and measured at 58 (±5.8) GtCO2eq in 2018. The group of fluorinated gases have jointly grown much faster than all other GHGs, and make a substantial contribution to global warming today. Continuing the recent global CO2 emission trends, the remaining carbon budgets for keeping 15 warming below both 1.5°C and 2°C will be swiftly exhausted. This is an impressive Chapter. Not a single country currently achieves sustained GHG emission reductions at rates commonly found in climate change mitigation scenarios that limit warming to well below 2°C. Figures 2 Annual global CO2 emissions from different global CO2 emissions data sets is important to clarify the annual global emissions for 10 years from 2006 till 2016. Also, Figure 2.2 Total anthropogenic GHG emissions (Gt CO2eq/yr) 1990-2017: CO2 from fossil fuel which increases from 38GT to 58GT during 18 years. Also, Figure 2.3 Historic anthropogenic CO2 emission and cumulative CO2 emissions (1850-2018) as well as 3 remaining carbon budgets for 1.5°C and 2°C. Figure 2.4 needs to be clear because the data are not clear in the graphs. Figure 2.5 Change in regional GHGs from multiple perspectives and their underlying drivers is very clear and representative. Figure 2.6 Change in CO2 emissions from fossil fuel combustion for the 18 countries in the peak-and decline group is clear, but didn't involve any countries in Africa, Soth America & Australia. Figure 2.7 Total annual anthropogenic GHG emissions by major economic sector and their underlying drivers. Box 2.3 Policy relevance of PBE and CBE accounts is an impressive box. Figure 2.9 Consumption-based CO2 emission trends by region for the period 1995-2016 is very impressive clarifying that CBE is very small compared to Developing countries & Asia. Figure 2.14 Changes in net emissions embodied in South–South trade and largest South–South transfers is impressive.It clarify the trend of emissions from 2004, increased in 2007 and more increasing in 2011. Figure 2.15 CO2 CBE estimates from Eora, EXIOBASE, GTAP, OECD, WIOD and the Global Carbon Budget for 40 countries is an impressive graph. Figure 2.19 Kaya decomposition of main drivers of global emissions growth between 1990 and 2018 clarifies the changes relative to 2000. Figure 2.20 is not clear, needs some other work . Figure 2.21 Global CO2 emissions from fossil fuels by fuel type and sector for the period 1970-2018 is not clear too, needs more clarifications . Figure 2.23	Noted. Thank you	Risk	Mounir Wahba Labib	National Academy of Science, Egypt	Egypt
14147	1		142		It is extremely surprising that the variable which is identified as the most important driver of GHG emissions in Chapter 2 is considered as exogenous in climate scenarios (see Annex C). This requires an explanation since an obvious policy to reduce GHG emissions derived from this empirical fact would be to design societies which are not dependent on GDP growth.	Noted, but to be addressed by chapter 3. But I note that I do not share the conclusion drawn from the empirical evidence. We need to get to net-zero. No-GDP growth scenarios will us not bring there either. In fact, there is ample scenario evidence that lo- or no-growth scenarios do not fundamentally change the mitigation challenge. I would argue they make the required investments more difficult.	Capellán-Pérez	Iñigo	University of Valladolid	Spain
18413	1		142		As the data of emissons can be easily found, It is suggested to illustrate the data on emissons from no later than 1900 for all the figures in the whole chapter.	It is a WGIII decision that we mainly focus on the time period 1990-2018 - and particularly on 2010-2018 as post ar5 period.	Shiyan	Chang	Tsinghua University	China
18421	1		142		There are two kinds of GHG calaculation methods have been used: production based and consumption based. It is necessary to clarify which method used in the subsequent section, for example, the sector emissions.	Accepted, clarification provided.	Shiyan	Chang	Tsinghua University	China

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
43705	1	1			Nice chapter. Consider to include the recent insight that anthropogenic methane emissions is higher than previously estimated: https://www.nature.com/articles/s41586-020-1991-8 and Alvarez, R. A. et al. Assessment of methane emissions from the U.S. oil and gas supply chain. Science 361, 186–188 (2018).	noted	Creutzig	Felix	MCC Berlin	Germany
1287	1				Chapter is too long, Consider compacting also a lor of overlap with chapter 3	Accepted, overlaps reduced to the necessary minimum.	BOSETTI	VALENTINA	BOCCONI -eiee	Italy
34979	2	4	2	4	Coupling USA to 17 European countries in terms of decoupling Co2 emissions and economic growth either needs to be dropped or explained as USA have some of the highest per capita emissions globally and compared to some European countries.	Rejected. We focus here on de-coupling and cannot explain all the different countries. Reasons why countries decouple are varied. Policy chapters could being helpful insights there.	Hancock	Linda	Centre of Excellence on Electromaterials Science Deakin University	Australia
35725	2	4	2	4	Coupling USA to 17 European countries in terms of decoupling Co2 emissions and economic growth either needs to be dropped or explained as USA despite decreasing emissions wih gas replacing coal, the US has some of the highest per capita emissions globally and compared to some European countries. This may need to be more nuanced.	Rejected. We focus here on de-coupling and cannot explain all the different countries. Reasons why countries decouple are varied. Policy chapters could being helpful insights there.	Hancock	Linda	Centre of Excellence on Electromaterials Science Deakin University	Australia
34981	2	6	2	6	Looking at the top 10% of global wealthiest needs to be clear this relates to people and not companies?	Accepted. Text was modified to clarify this.	Hancock	Linda	Centre of Excellence on Electromaterials Science Deakin University	Australia
5179	2	7	2	7	Publication year should be added to Collins et al.	Apologies. I cannot locate the position of the text you are referring to.	Alataş	Sedat	Aydın Adnan Menderes University	Turkey
36417	2	9	2	9	FFI: useful to use unintroduced abbrevations in executive summary? See comment above	Accepted. Tried to always write out abbreviations the first time used.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
38765	2	10	2	10	Does FOLU include agriculture? If not, where are emissions from agriculture and/or working lands represented?	Accepted. We now refer to CO2 from AFOLU. Thanks	Reyes	Julian	Personal Capacity	United States of America
41055	2	7	2	13	I don't find these contributions to total CO2 equivalent emissions very meaningful. You may consider different ways of presenting the "big picture" for emissions. This is something that can be discussed with WGI	Noted, but we have to cover a high-dimensional space in WG3 - different than in WG1. Aggregation is required more frequently.	Fuglestvedt	Jan	CICERO	Norway
1769	2	17	2	17	Add pt. 2.4.3 "Socio-Cultural Drivers"	Noted [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors. Cultural elements have been included in the behaviour section 2.6]	Bharat	Alka	Department of Architecture & Planning, M.A.National Institute of Technology (An Institute of National Importance),Bhopal (M.P.)	India
1771	2	18	2	18	modify pt. 2.4.3 as 2.4.4 and other succeding points accordingly	Noted [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors. Subheadings have changed accordingly]	Bharat	Alka	Department of Architecture & Planning, M.A.National Institute of Technology (An Institute of National Importance),Bhopal (M.P.)	India
41053	2	14	2	21	Please check consistency with WGI ch5 and WGIII ch3.	Accepted. We are consistent with WG1 SOD.	Fuglestvedt	Jan	CICERO	Norway
1773	2	25	2	25	and the speed … ?	Rejected, not clear what is this comment referring to.	Bharat	Alka	Department of Architecture & Planning, M.A.National Institute of Technology (An Institute of National Importance),Bhopal (M.P.)	India
16697	2	29	2	36	The organization of 2.7-2.9 is not quite consistent with the overall structure of this chapter. In particular, the introduction sections are somewhat odd here, whichcould be included in the Section 2.1 (Line 4)	Taken into account. Restructuring of the section structure is under discussion and will be finalized after SOD review. Highly likely to delete subtitle of 'introduction'.	Ma	Leiming	Shanghai Central Meteorological Observatory	China
33139	2		9		The summary is extended and excellent	Noted.	Alam	Edris	Rabdan Acadmey	United Arab Emirates
18827	2		56		There exists a high correlation between poverty and Green house Gas emissions. Oftentimes, poor enlightenment campaigns triggers ignorance on Green house gas emissions by the destitute. In addition, most poor homes tend to emit green house gas unintentionally with the major intention to provide basic means of survival for their family dependents.	Accepted [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors. Subsection 2.4.3 on inequality deals extensively with poverty]	Ugom	Michael	University of Nigeria, Nsukka	Nigeria
14911	2		142		Emissions of individual short-lived climate forcers (SLCF) are missing although metrics for SLCF are discussed rather extensively. These should be included since their levels and trends are equally important in the context as those of long-lived greenhouse gases.	Accepted. We have added a short section on this.	Foltescu	Valentin	UNEP/CCAC	India

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31163	2	39			In figure caption: specify (a), (b), and c); make the lables 2004, 2007 and 2011 in the fitures more visible	Accepted, figures will be improved.	Ruth	Urs	Robert Bosch GmbH	Germany
1285	2				Figure 2-1 Linkages between the emission trends and the multi-dimensional drivers: unclear figure, caption is misleading...no linkages are shown. Either drop or change it	accepted, figure improved.	BOSETTI	VALENTINA	BOCCONI -eiee	Italy
2295	4	2	4	2	GHG emissions UNTIL 2018 were the highest … (unfortunately the peak was likely not reached in 2018)	Accepted	Martinerie	Patricia	CNRS	France
40105	4	3	4	3	The "medium confidence" should be "medium confidence interval" as 'medium confidence' is incomplete and confusing for readers. Also the high, medium and low confidence interval range of each interval needs to be given on the first page of the chapter as a note.	Rejected. This is consistent with IPCC uncertainty language.	Pandey	Neeraj	National Institute of Industrial Engineering (NITIE), Mumbai	India
27509	4	2	4	6	This CO2-eq figure is very dependent on the metric used. It would be much more transparent to give this as CO2-only by using the numbers from the next ES point.	Rejected. As WG3 data has higher dimensionality (sector, regions/countries) it is often not possible to report gases separately. However, we have a box on emission metrics as well as an Annex, where this important issue is comprehensively addressed.	Collins	William	University of Reading	United Kingdom (of Great Britain and Northern Ireland)
31913	4	2	4	6	Summary statements need to give the breakdown into long-lived and short-lived pollutants, or at the very least say "of which XXX is due to long-lived cumulative pollutants including CO2 and N2O." Giving this breakdown is necessary to assess the temperature implications of emission trends, and hence track progress to achieving the long-term temperature goal of the Paris Agreement. Aggregate CO2-e emissions alone do not predict warming.	Rejected. It is not our purpose here to predict warming and we believe that the way of reporting is adequate. However, we have added a section on SLCFs in the chapter and run WG3 emissions data through WG1 models (new Figure in Section 2).	Allen	Myles	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
26151	4	7	4	8	Please, if possible give a figure of the current emissions and trend for fluorinated gased	Noted. There is a figure on that in the chapter, which we now reference.	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
30029	4	7	4	8	why focus on fluorinated gases?	Because they grew considerably and much faster. There was some imprecise language on f-gases which we have corrected now.	Metz	Bert	European Climate Foundation	Netherlands
24471	4	9	4	9	FFI should be mentioned in full text instead of abbreviation to every audience understand as it is firstly appeared.	Accepted	WIN	SAN	Environmental Conservation Department, Ministry of Natural Resources and Environmental Conservation	Myanmar
26153	4	9	4	9	Acronym FFI used for the first time. Not obvious for non IPCC readers	Accepted	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
27511	4	9	4	9	The CO2 numbers are separated into FFI and FOLU. Are the CH4 and N2O numbers from FFI and FOLU combined? - the sentence is not clear.	Thanks. We tried to clarify.	Collins	William	University of Reading	United Kingdom (of Great Britain and Northern Ireland)
30831	4	9	4	9	Using these abbreviations like FFI and FOLU without explanation is unclear, and may be mistaken for types of f-gas. It would be simpler to collect all CO2 results together here, since we're really comparing CO2 and non-CO2 emissions?	Accepted	Lamboll	Robin	Imperial College	United Kingdom (of Great Britain and Northern Ireland)
26803	4	9	4	10	Please be careful of English expression here and throughout. Precise language will lead to greater understanding. Emissions are not tracking in 2018, they simply are. Track means to roughly follow a path and these numbers do not refer to a path.	Noted	Verchot	Louis	International Center for Tropical Agriculture	Colombia
26155	4	11	4	11	Please give the period of this growth.	Accepted	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
26805	4	11	4	11	By saying that CH4 and N2O emissions "only" increased by 24% and 28% makes it sound like this increase is unimportant. Be careful with percentages for the F gases, it does not take much to increase a small number by a large percent.	Accepted	Verchot	Louis	International Center for Tropical Agriculture	Colombia
30925	4	7	4	13	The paragraph is not clear you hint at fluorinated emissions but you speak about all the sector. I would state there that the FFI is still the higher emitter and also I would explain what means the abbreviation FFI	Noted. We changed the emphasis of the finding.	Bartocci	Pietro	University of Perugia	Italy
36683	4	7	4	13	please ensure that these emission changes are consistent with those in the SOD of WG1 (chapters 5 and 6)	Noted. Specific numbers can be different as we work with different datasets. However, we have added a section on uncertainties in the chapter, where we compared all major datasets. WG1 authors were involved.	Naik	Vaishali	NOAA GFDL	United States of America

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45165	4	7	4	13	The last sentence contains important information and perhaps should be put early on in the paragraph.	Noted, but we changed emphasis away from f-gases a bit-	Singfoong	Cheah	Independent consultant, formerly more than 10 years with the National Renewable Energy Laboratory, USA	United States of America
45167	4	12	4	13	Can we say how "much (%, effect)" of the warming due to F-gases is in the scenario that it was not being abated fast enough?	Noted. This is not scenario data. We have a new figure in the chapter on warming contributions. But we do not include this here in the ES.	Singfoong	Cheah	Independent consultant, formerly more than 10 years with the National Renewable Energy Laboratory, USA	United States of America
45903	4	12	4	13	The wording "Today (...) contribute to warming at similar scales" can be confusing, as in a WGI perspective "contributing to warming today" would mean that F-gases and N2O cause similar radiative forcing today (this is a logical definition of 'warming'). What you mean is that F-gases and N2O contribute to rougly the same amount of emissions as CO2-eq. This means that emissions today will contribute to warming at a similar scale in the future (over the next 100 years). That may be solved by just writing "emissions (increasingly) contribute to future warming at similar scales".	Accepted	Marbaix	Philippe	UCLouvain, Belgium	Belgium
1911	4	14	4	14	This paragraph makes a point about the consequences of continuing emissions at the current rate, not trend; suggest replacing trends with rate.	Accepted	Kheshgi	Haroon	ExxonMobil Research and Engineering Company	United States of America
30031	4	14	4	15	the message about 7% annual reduction for 1.5 C plus substantial CO2 removal is much more relevant; so move that tekst into the headline	Accepted, but we do not mention CDR in the headline as it is not at the core of the remit of the chapter.	Metz	Bert	European Climate Foundation	Netherlands
2297	4	15	4	15	"At current rates" - what is current changes everyday, define current (e.g. 2018)	Accepted. We calrified that-	Martinerie	Patricia	CNRS	France
36685	4	15	4	15	"swiftly exhausted" needs to be quantified	Rejected. This is clarified in the subsequent statement after the headline	Naik	Vaishali	NOAA GFDL	United States of America
30833	4	17	4	17	Adding "respectively" after "9 and 27 years" would increase clarity	Accepted	Lamboll	Robin	Imperial College	United Kingdom (of Great Britain and Northern Ireland)
30835	4	17	4	17	The means by which these values are calculated is somewhat crude (assumes complete stagnancy - i.e. your calculation is for the current level of emissions, not including the derivatives that might be implied by 'current trends') and will likely not be consistent with WG1 results. Please ensure consistency and emphasise stagnancy, particularly when this topic comes up again in the main body of the text.	Noted.	Lamboll	Robin	Imperial College	United Kingdom (of Great Britain and Northern Ireland)
31915	4	17	4	17	Giving a single number for the remaining carbon budget for 1.5C repeats the mistake made in AR5 which has caused so many problems since. The suggestion that the budget for 1.5°C will be exhausted in 9 years implies that we expect 0.4°C of warming to be associated with 390 GtCO2 cumulative emissions, or a TCRE of 1°C per TtCO2, which is far above the top end of the TCRE range (0.23-0.68°C in AR5). The closer we get to exhausting the budget, the less plausible it is that the discrepancy can be explained by the impact of other pollutants. The 9 years budget only makes sense if we redefine global temperature in terms of GSAT to halve the remaining warming to 1.5°C -- but this decision has such profound implications that it cannot be taken by a small group of IPCC authors alone. The solution is to quote, at minimum, central tercile ranges (so budgets for both 66% and 33% chance of limiting warming to a given level) using both GMST and GSAT definitions of global temperature, highlighting both the uncertainty and the sensitivity to definition.	Accepted	Allen	Myles	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
14549	4	17	4	18	"This assumes the absence of any CO2 removal" is wrong and seems to confuse how global net emissions are defined. Already today, global CO2 emissions cited in the previous sentence are the net amount of emissions and removals. This sentence is hence unsupported and internally inconsistent.	Accepted and removed	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
43373	4	18	4	18	I believe you mean 'assumes the absence of any anthropogenic CO2 removal'?	We removed this.	Honegger	Matthias	Perspectives Climate Research gGmbH	Germany

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
32383	4	14	4	21	According to Table 2.2 in the IPCC Special Report on 1.5C, non-CO2 emissions and Earth system feedbacks like permafrost thaw can further decrease the carbon budget, making achieving the goal of limiting warming to 1.5ºC that much more difficult. See also Pistone K., et al. (2019) Radiative Heating of an Ice-Free Arctic Ocean, GEOPHYSICAL RESEARCH LETTERS 46(13):7474–7480 (calculating the loss of all sea ice for the entirety of the sunlit months could add the equivalent of 1 trillion tons of CO2). Similarly, early saturation of land sinks, and the transition to sources, also can reduce the carbon budget and the time to achieve net zero emissions. See e.g., Wannes Hubau, et al. (2020) Asynchronous carbon sink saturation in African and Amazonian tropical forests, Nature.	Noted. We now highlight scenario uncertainty.	Zaelke	Durwood	Institute for Governance & Sustainable Development	United States of America
32761	4	14	4	21	Per the IPCC Special Report on 1.5C, non-CO2 emissions and key feedbacks like thawing permafrost can further decrease the carbon budget, making achieving the goal of 1.5C that much more difficult.	Rejected. We now provide a better representation of uncertainties, but details of carbon budgets are dealt with in WG1.	Campbell	Kristin	Institute for Governance & Sustainable Development	United States of America
14551	4	18	4	21	To stay within a finite carbon budget, CO2 emissions need to decline to (net) zero. An exponential decline as suggested here is a mathematical functional form that will never reach net zero except ad limens in infinity. This is thus not an appropriate functional form to describe this reduction. I am well aware that many times compound annual decline rates are used in communication around this issue, but given that the IPCC has to critically assess the available evidence, the authors in this chapter are not bound to commit the same conceptual error. In IPCC SR15, instead linear decline rates were reported, relative to a fixed recent reference year. That mathemical formulation can adequately describe a decline to zero and beyond.	Accepted, we changed the way we calculate these. Still, we point that there is not right or wrong with that - as there is a lot of evidence that suggests: a) that emission reductions become harder as we go deeper; b) gross residual emissions might be impossible to get to zero. Our accounting data does not comprehensively cover removals.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
14553	4	22	4	23	There's a tension between the use of the word "currently" and "sustained" in the sentence. I would suggest to reword so that it says: Over the past three decades, not a single country has achieved sustained GHG emission reductions at rates commonly found in climate change mitigation scenarios that limit warming well below 2°C. I would also suggest to make the headline statement refer to the Paris Agreement and put the well below 2°C (or 1.5°C) in the body of the key message.	Thanks - dealt with.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
17595	4	24	4	25	The meaning is ambiguous but presumably means, “compared to 1990”. Most countries increased emissions to 2000, not least because there was no substantive international framework, though already there were exceptions. Some industrialized continued to increase emissions the following decade. Most have reduced since 2010. I think that is an extremely important distinction that cannot be captured by “since 1990 …”	This part of the assessment has been removed.	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
17597	4	26	4	27	Small but growing? The chapter refers to 18 .. say so	Taken on board	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
15917	4	22	4	29	In sentence: "Not a single country currently…." it is better to quantify the number of countries (it can be in %), ex. Only 10% country currently……	Accepted. We have done so now	Takarina	Noverita	Universitas Indonesia	Indonesia
17593	4	22	4	29	Authors need to check this. The UK has achieved national CO2 emission reductions averaging 3.3%/yr compound over the past decade, resulting in a 29% overall CO2 reduction over the period (2010-2019). Online source: https://www.carbonbrief.org/analysis-uks-co2-emissions-have-fallen-29-per-cent-over-the-past-decade. Such recent data are not available on consumption-based emissions, but the general data sources reported in this chapter suggest that the UK embodied imports ceased to grow around 2005. And, I think clarify, “A small number of countries show sustained GHG emission reductions” . p.25 line 7 you report “18” countries as shown in Fig 2.6	Noted. We worked a lot on this part of the assessment and have revamped the entire finding. Hope this addresses the concerns now.	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
37159	4	22	4	29	Not all countries are assessed in 2.2.2. Therefore this statement is too general. Furthermore, it is not clear how 'typical' rates are defined and over what timeframe. A timeframe starting in 1990 might not be appropriate, given that no climate policy was in place back then. As an example, the UK has reduced by about 2.9% per year over the last decade, which, if sustained, should be pretty much in line.	Noted. We worked a lot on this part of the assessment and have revamped the entire finding. Hope this addresses the concerns now.	Schaeffer	Michiel	Climate Analytics	Netherlands
14555	4	30	4	31	A very interesting additional perspective to show is how consumption-based emissions differ between global income classes. I don't know if there's data available to inform this, but it would provide extremely valuable information that goes beyond the country level and makes a clearer link to life styles of individuals rather than development stages of countries.	Section 2.7 provides this information on global income classes.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
30033	4	31	4	32	how is consumption based defined?	Accepted. A defination of consumption-based emissions has been added in the text, as well as othe scopes of emissions.	Metz	Bert	European Climate Foundation	Netherlands
3141	4	30	4	35	The key figures presented in this paragraph such as "17Gt in 2007", "10% decline by 2015", "46% of global emissions", "41% from middle-income countries" and "1% from low-income countries" are not discussed or clearly indicated in the main text of Section 2.3.1. Also, the statement "Middle-income countries have been a major contributor to CO2 emission growth since 2000" cannot be found in the main text. Please consider revising either this paragraph or the main text.	The classification of countries has been changed. Not applied.	LEE	Sai Ming	Hong Kong Observatory	China
37161	4	36	4	37	And so do some dev'ing countries. E.g. Costa Rica is coming very close to stabilising there emissions.	Accepted and revised.	Schaeffer	Michiel	Climate Analytics	Netherlands
47487	4	36	4	37	It should be clarified whether the mentioned "absolute decoupling" refers to consumption-based emissions (as would follow from the previous paragraph) or territorial-based emissions.	Accepted and revised.	Rakonczay	Zoltán	European Commission, Directorate General for Research	Belgium
35843	4	37	4	38	USA is not growing economically that fast anymore (being a developed economy). The growth happens in China and other developing nations. The USA imports those growth emissions. They are more into service sector and there is data available even with the UNFCCC as to how manufacturing units have declined in Annex I countries in the past few years. But the consumption is rising. So where is the need being fulfilled from? Should we call this decoupling? We need to answer these questions to avoid setting a wrong precedent. This will further encourage a free-rider country like the USA to not take any action.	Accepted. We discussed CBE. Text revised.	Gupta	Himangana	Institute for the Advanced Study of Sustainability, United Nations University, Tokyo	Japan
26807	4	36	4	41	If the paragraph on page 5, line 2 is true than this paragraph cannot be true. If countries are exporting emissions through globalization of production chains, then their economic growth is fueling emissions beyond their borders. Just because we account for GHGs at the national scale, we cannot say that developed country growth has been decoupled from emissions. It is an artefact created by the quirks of how we do the accounts.	Rejected. We calculate the decoupling of economic growth with both production- (PBE) and consumption-based emssions (CBE). CBE caputures the emissions embodied in global trade. Some developed countries have coupled economic growth from PBE, but not CBE.	Verchot	Louis	International Center for Tropical Agriculture	Colombia
39649	4	36	4	41	It could be clarified if this is true for territorial, production and/or consumption based emissions.	Accepted and revised.	Davidsson Kurland	Simon	Chalmers University of Technology	Sweden
46451	4	36	4	41	This paragraph inappropriately claims that decarbonization and economic prosperity of levels achieved by rich nations are incompatible based on some "carbon budget" to keep warming well below 2 degrees. That is nonsense. The underlying idea is that poor nations must sacrifice economic growth, which is unacceptable and outrageously Malthusian. It is also unsupported by the evidence from France, Sweden and other nations.	We agree that developing countires can also achieve decoupling, no need to sacrifice their economic growth. We revised the text.	Shellenberger	Michael	Environmental Progress	United States of America
3143	4	37	4	41	The statements given in this paragraph do not seem to have been concluded from the discussions in the main text of Section 2.3.1. Please consider revising this paragraph or the main text.	Accepted and revised.	LEE	Sai Ming	Hong Kong Observatory	China
17601	4	38	4	41	Again, there is “devil in the aggregation”. Many EU countries have per-capita emissions 1/3 of the US level, and lower than, for example, China. UK emissions are now lower than they were in 1888 (yes, 150 years ago). Consequently, the subsequent sentence depends on what you mean by “role model”. The entire foundation of the UNFCCC was based on a principle of industiralised country leadership … by definition, they started from a higher base level	Accepted. We calculated the decoupling index for every single country to avoid the 'devil in the aggregation'.	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
24469	4	3	4	42	Abbreviation of Global Warming Potential - GWP should be mentioned in the reference 'a' below line 41 as GWP is mentioned in many pages of the chapter 2.	noted	WIN	SAN	Environmental Conservation Department, Ministry of Natural Resources and Environmental Conservation	Myanmar
2293	4	1	7	23	The executive summary lacks a synthesis of most promising directions and largest barriers to strongly reduce GHG emissions in the near future, although interesting elements are provided in the chapter	Rejected. This is not the remit of our chapter, but of chapter 2 and 3 as well as the sector chapters.	Martinerie	Patricia	CNRS	France
3201	4	1	7	23	Congratulations to the team that prepared this executive summary. It has a very good structure, uses a language that is easy to understand and provides very relevant und important insights	Thank you!	Radunsky	Klaus	retired from Umweltbundesamt	Austria

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
15923	4	1	7	23	In general, the report should include how the current global pandemic can also be emissions drivers	Accepted. We have now also synthesized evidence on how the pandemic has influenced emission trends.	Takarina	Noverita	Universitas Indonesia	Indonesia
41051	4	1	7	23	The ES is well written and has a nice format with one clear bold sentence in each para. Hope this can be used thoughout the report	Thank you!	Fuglestvedt	Jan	CICERO	Norway
16193	4	1	7	24	Consider adding a paragraph to the Executive Summary of Chapter 2, describing the fraction of GHG emissions that are tied to military activities globally. If this information is not readily available, an estimate with error bars ought to be added. Not including emissions from military activities hinders an accurate accounting of GHG emissions. That governments need to work together to address climate change is tied in with military emissions, such as those from rocketry (e.g. to launch satellites and missiles) and transport, plus provisioning, communications, etc.	Rejected. This is beyond the outline that was given to the chapter and I am not aware of large scientific body of evidence on this.	Helman	Daniel	College of Micronesia-FSM	Micronesia, Federated States of
30023	4	1	7	24	Fluorinated gases are singled out for a special mention, but rapidly-rising CH4 is not specifically addressed. This may require it's own summary paragraph. The following references may be useful to summarise this, and to add detail and context later in Chapter 3 - 1/ Nisbet, E.G., Manning, M.R., Dlugokencky, E.J., Fisher, R.E., Lowry, D., Michel, S.E., Myhre, C.L., Platt, S.M., Allen, G., Bousquet, P. and Brownlow, R., 2019. Very strong atmospheric methane growth in the 4 years 2014–2017: Implications for the Paris Agreement. Global Biogeochemical Cycles, 33(3), pp.318-342. 2/ isbet, E.G., Fisher, R.E., Lowry, D., France, J.L., Allen, G., Bakkaloglu, S., Broderick, T.J., Cain, M., Coleman, M., Fernandez, J. and Forster, G., 2020. Methane mitigation: methods to reduce emissions, on the path to the Paris Agreement. Reviews of Geophysics, 58(1), p.e2019RG000675. 3/ Schwietzke, S., Sherwood, O.A., Bruhwiler, L.M., Miller, J.B., Etiope, G., Dlugokencky, E.J., Michel, S.E., Arling, V.A., Vaughn, B.H., White, J.W. and Tans, P.P., 2016. Upward revision of global fossil fuel methane emissions based on isotope database. Nature, 538(7623), pp.88-91. I would suggest these key recent CH4 summary papers are referenced and discussed in this chapter. Particular focus on CH4 could include the changing role of CH4 FF fugitives (and the rise of shale gas in the US) and on natural feedbacks - tropical and high latitude wetlands.	Rejected. We do not single out f-gases. We cover all major GHGs. Thanks for the references. Noted	Allen	Grant	University of Manchester	United Kingdom (of Great Britain and Northern Ireland)
14563	4		7		A very nice Executive Summary with good, concise, traceable and extremely relevant insights!	Thank you!	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
25507	4		7		Can a paragraph covering Short-Lived Climate forcers be added to the this executive sumary? SLCFs are a cross-Working Group topic that are responsible for key differences in mitigation pathways and how global tempteratures can respond. For example, please see the WGI SOD chapter 6 and Sections C and D of the WGI SPM.	Rejected. But we added a section on SLCFs in the main body	Connors	Sarah	IPCC WGI TSU	France
43585	4	2	8	20	Given the improbability of achieving the reduction in GHG emissions needed to achieve the goals of the Paris Agreement the Report should discuss the politically challenging issue of solar geoengineering as discussed for example by Mac Martin et al in ISSN 1469-3096 (Print) 1752-7457(Online) Journal homepage: https://www.tandfonline.co,/loi/tcpo20	Rejected. This is not the remit of this chapter. We do not cover SRM.	Green	John	Royal Aeronautical Society	United Kingdom (of Great Britain and Northern Ireland)
19757	4	2		6	WGI includes similar statistics for annual CO2 emissions and their changes - ensure consistency.	Noted. We are in touch with WG1 colleagues. Our team consists of lead figures of carbon budget, methane budget and n2o budget.	Gillett	Nathan	Environment and Climate Change Canada	Canada
15667	4	12		13	GWP-weighted CO2-equivalent annual emissions may not be the best metric for calculating the relative contributions of different gases to current warming. For the historical contributions, these are assessed in WGII. In terms of the effects of current emissions.	Noted. We discuss this at length in a box on emission metrics and explain why we use this approach.	Gillett	Nathan	Environment and Climate Change Canada	Canada
15673	4	36		37	Not clear to the non-specialist reader what 'absolute decoupling' means. Could this be expressed more simply by saying that these countries have experienced GDP growth while their emissions have stabilised or declined?	Accepted and revised.	Gillett	Nathan	Environment and Climate Change Canada	Canada
45503	4	36		41	The future trend of CO2 emissions from the developed country is certain Future trend and present projections of allthe 19 European countries including the United State of America must be stated in the table, measures for future trends, analysis based on the decoupling of CO2 emissions in relation to GDP growth, which could further help the developing countries to archive better growth in CO2 decoupling and decarbonization. They might not be a role model for decarbonization but the future of Zero CO2 emissions to keep the warming below 2°C.	Reject. In our chapter, we only discussed the historical trends of emissions in countries.	Adegoke	Abiodun	Samsung electronics West Africa	Nigeria

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
17591	4	6			I suggest adding a short caveat, “However, there are large national and regional differences in trends”	Rejected. We want to focus on global trends here.	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
1963	4	10			Please, indicate the reference year for the percentage growth of emissions (e.g. a growth of 66% for CO2 but from which year?).	Accepted.	Savolainen	Ilkka	Tech.Res.Ctr. of Finland VTT, emeritus research professor	Finland
15671	4	30			I suggest including a few words to define what consumption-based CO2 emissions are.	Accepted and revised.	Gillett	Nathan	Environment and Climate Change Canada	Canada
17599	4	30			Surely, it is “most” ? Indeed which ones haven’t decoupled?	Rejected. We can't include very detailed information in th ES due to word limits.	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
15669	4	32			Specify the metric used here. Is the GtC (of CO2), or Gt CO2?	Accepted. Will specify.	Gillett	Nathan	Environment and Climate Change Canada	Canada
10305	4				The Executive summary is well written, but has a tendence to pack too many different issues into a single paragraph. As a result, some conclusions appear more disjointed and repetitive than they need to be. Key examples include findings relating to trade/consumption/embodied emissions, the role/relevance of income levels of countries for different issues, demographic and sustainable development factors, amongst others. In some instances, key caveats or explanatory elements are spread across different paragraphs. It would be helpful if the authors could focus on the key narrative/themes and key points they wish their ES to convery and re-construct paragraphs accordingly, rather than each para representing a summary of individual sections.	Accepted. The ES has been rewritten.	Reisinger	Andy	NZAGRC	New Zealand
30035	5	1	5	1	how defined vs consumption-based?	Accepted. We need to clarify that this is emissions per unit of output, which is production based in this case.	Metz	Bert	European Climate Foundation	Netherlands
30037	5	6	5	7	Much more relevant to discuss consumption patterns in developed countries and the supply chains that are needed for that; the current framing is misleading	Rejected: There is a satement along those lines referring to section 2.6 later in the executive summary.	Metz	Bert	European Climate Foundation	Netherlands
32185	5	9	5	9	"division of labor" seems inappropriate. It sounds as some division of this sort has been agreed internationally, which is not the case.	Rejected. This is a standard phrase.	DUBE	LOKESH CHANDRA	NATCOM Cell, Ministry of Environment, Forest and Climate Change, Government of India	India
4959	5	8	5	11	The flow of embodied emissions in trade is also caused by more emissions intensive production processes in developing countries, especially China and India where 60% + of primary energy is sourced from coal. Consumption based emissions only provide weak evidence on the pollution haven effect/hypothesis. We need to also compare emissions adjusted for technology at least.	We do not attempt to assess the pollultion haven hypothesis. The emission intensity of these countries is included in the statement "where emission-intensive processes are increasingly carried out in developing countries". We will update the text based on the latest literature. Here is one on NCC. Kander, A., Jiborn, M., Moran, D. D. and Wiedmann, T. O. (2015) National greenhouse-gas accounting for effective climate policy on international trade. Nature Climate Change, 5(5), 431-435. http://dx.doi.org/10.1038/nclimate2555	Stern	David	Australian National University	Australia
2299	5	6	5	13	The related evolution(s) of carbon intensity could be mentioned	Accepted. We have put forward a figure with changes of 25 year period.	Martinerie	Patricia	CNRS	France
18351	5	6	5	13	The lead sentence of this paragraph is too simplified because section 2.3.3 and Figure 2.14 show net emissions embodied in South–South trade and transfers, but they are reflected only at the end end of paragraph.	Accepted. We use a more detailed country classification (e.g. the one from the World Bank) this changes. Thus this will be revised.	Hombu	Kazuhiko	Graduate School of Public Policy, The University of Tokyo	Japan
26157	5	6	5	13	This is an interesting paragraph. Is it possible to quantify these emissions	Accepted. The emissions have been quantified in the literature. Will add the numbers.	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
1913	5	14	5	14	It is not clear why affluence is included in addition to economic growth. Suggest deleting affluence.	Rejected [Affluence is GDP per capita and therefore different to GDP. Literature confirms the importance of affluence as a driver, see Section 2.4.1, reviewer comment 2317 and this recent publication as an example: Wiedmann, T., Lenzen, M., Keyßer, L. T. and Steinberger, J. K. (2020) Scientists' warning on affluence. Nature Communications, 11(1), 3107. https://doi.org/10.1038/s41467-020-16941-y or https://rdcu.be/b43Hh]	Kheshgi	Haroon	ExxonMobil Research and Engineering Company	United States of America
26159	5	14	5	15	Among the drivers, the structure of the economy seems to be important. For instance oil exporting countries, former Easter European countries have an economy structure which is more conducive to higher GHG.	Noted [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors, incl. the effects of production structure where relevant. However, since it is not a major, general driver, this has not been included in the Exec Summary]	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
30039	5	14	5	15	The big missing element here is the carbon intensity of energy, driven by continued investment in new fossil resources. Tis needs to be strongly highlighted	Rejected [As the Kaya decomposition in Section 2.4 shows, the carbon intensity of energy is the factor that least influences the change of CO2 emissions and that has changed the least in the last 30 years. Details are discussed in the Section.]	Metz	Bert	European Climate Foundation	Netherlands
47489	5	15	5	17	The mentioned "long-term trend" is important, but why is it limited to the period since 1990? Would this not hold to the whole industrial period? A reference to the Jevons Paradox could be useful to contextualise the issue.	Taken into account – text revised [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors. The Exec Summary will be updated accordingly]	Rakonczay	Zoltán	European Commission, Directorate General for Research	Belgium
1915	5	18	5	20	It is unclear if the 2012 peak in coal stated was a local maximum or if it has never been exceeded. Suggest clarifying and restating if it has been exceeded or if there is a likelihood of it being exceeded in the near term.	Noted [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors. AR6 is mostly interested in what happened since AR5 (ca. 2014) and the Exec Summary should focus on the changes since then. Starting the Kaya decomposition in 1990 is also determined by data availability]	Kheshgi	Haroon	ExxonMobil Research and Engineering Company	United States of America
17603	5	19	5	20	With last year's plateau, and bearing in mind this Report will not be published until late 2021, you might want to caution this phrasing? Indeed, I cant find statistics suggesting increased coal consumption since c. 2014, rather the reverse even at global level	Accepted – text revised [This statement was backed up by Peters et al. 2019, but we will check the latest IEA data and publications as well when revising . (Peters, G. P., R. M. Andrew, J. G. Canadell, P. Friedlingstein, R. B. Jackson, J. I. Korsbakken, C. Le Quéré, and A. Peregon, 2019: Carbon dioxide emissions continue to grow amidst slowly emerging climate policies. Nat. Clim. Chang., https://doi.org/10.1038/s41558-019-0659-6)]	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
24807	5	20	5	20	Delete ", due to increased … use of oil."	Accepted – text revised [This statement was backed up by Peters et al. 2019, but we will check the latest IEA data and publications as well when revising . (Peters, G. P., R. M. Andrew, J. G. Canadell, P. Friedlingstein, R. B. Jackson, J. I. Korsbakken, C. Le Quéré, and A. Peregon, 2019: Carbon dioxide emissions continue to grow amidst slowly emerging climate policies. Nat. Clim. Chang., https://doi.org/10.1038/s41558-019-0659-6)]	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
30041	5	21	5	22	Here also the carbon intensity of energy is missing; in developed countries carbon intensity is going down; in developing countries it is unclear, while costs of renewables are now lower in most places than fossil. Why is this happening? That should be highlighted	Taken into account – text revised [This statement was backed up by Peters et al. 2019, but we will check the latest IEA data and publications as well when revising. (Peters, G. P., R. M. Andrew, J. G. Canadell, P. Friedlingstein, R. B. Jackson, J. I. Korsbakken, C. Le Quéré, and A. Peregon, 2019: Carbon dioxide emissions continue to grow amidst slowly emerging climate policies. Nat. Clim. Chang., https://doi.org/10.1038/s41558-019-0659-6)]	Metz	Bert	European Climate Foundation	Netherlands
47491	5	23	5	24	The statement on developed economies would require an indication of uncertainty, in particular as it relates to consumption-based emissions.	Taken into account – text revised [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors, incl. their specific carbon intensities]	Rakonczay	Zoltán	European Commission, Directorate General for Research	Belgium
35837	5	23	5	25	This statement contradicts line 30 and 31 on Page 4. The consumption emissions of developed countries continuously increased. 1250 million tonnes of CO2 emissions were transferred from non-Annex I countries to Annex I countries from 1990-2012. China alone transferred more emissions than the negative transfers of the entire Annex I despite the Russian Federation being the major exporter in the group. The correlation of FDI with emissions was weak at 0.53 in 1990, strong in 2005 and 2012 at 0.95 and 0.93 respectively (https://www.epw.in/journal/2018/43/special-articles/estimating-greenhouse-gas-emissions.html). It is doubtful whether clean energy really played a role in reduction of emissions in developed countries as there is clear data to show that none of the countries, except European Union met their Kyoto Commitments, a large part of which was possible due to the addition of EIT Parties which had a very low emission level as compared to 1990s. Overall, the developing countries have been fulfilling the needs of the developed countries through exports and this needs to be highlighted clearly. For most developing countries, the increase in emissions has not substantially raised their standard of living, mainly because production did not feed their own population but just increased their GDP.	Taken into account – text revised [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors. The Exec Summary will be updated accordingly]	Gupta	Himangana	Institute for the Advanced Study of Sustainability, United Nations University, Tokyo	Japan
15919	5	28	5	29	When you state the relationship, this should be tested with statistic or meta analyisis that can provide robust evidence that relationship of GHG-demographic is significant.	Taken into account – text revised [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors. The Exec Summary will be updated accordingly]	Takarina	Noverita	Universitas Indonesia	Indonesia
30043	5	28	5	31	population growth should also be addressed	Taken into account – text revised [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors. The Exec Summary will be updated accordingly]	Metz	Bert	European Climate Foundation	Netherlands
30441	5	32	5	37	It is hard to understand what you are saying - double negatives, etc. Seem too concepts here, that eradicating poverty does not increase emissions, and that greater inequality can lead to more emissions. Is that correct? If so, can you say it more clearly/	Accepted – text revised	Cook	Lindsey	Quaker United Nations Office / Friends World Committee for Consultation (IPCC Observer)	Germany
35839	5	34	5	37	For example, inadequate access to clean energy can lead to biomass burning which does not account for in national GHG inventories but is a significant GHG emitter.	Noted [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors. Statements on statistical robustness need to rely on the published literature]	Gupta	Himangana	Institute for the Advanced Study of Sustainability, United Nations University, Tokyo	Japan
35841	5	38	5	40	Must focus on the benefits of decentralization like in Europe, which is unlike the way new economies are developing leading to urban heat islands.	Taken into account – text revised [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors. Population was added to the Kaya decomposition. The Exec Summary will be updated accordingly]	Gupta	Himangana	Institute for the Advanced Study of Sustainability, United Nations University, Tokyo	Japan
30045	5	38	5	41	would be interesting to know if lower transport emissions in cities and lower energy use in city housing has a compensating impact	Taken into account – text revised [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors. The Exec Summary will be updated accordingly]	Metz	Bert	European Climate Foundation	Netherlands

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
2301	5	44	5	44	I would say technological and investment change	Taken into account – text revised [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors. The Exec Summary will be updated accordingly]	Martinerie	Patricia	CNRS	France
36401	5	43	5	45	insert “energy” as ‘..much faster paced technological energy change..”. as this sentence refers explicitly to the energy sector	Taken into account – text revised [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors. The Exec Summary will be updated accordingly]	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
36403	5	44	5	45	unclear what means ‘earlier transitions’ as since industrial revolution and onset of massive GHG emissions no major transition has happened. Make cleare by adding explicit example. And potentially more clearly define what ‘earlier’ means. Major noticeable transitions in the energy sector has happened with the change from wood – coal to oil products atter the industrial revolution	Taken into account – text revised [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors. The Exec Summary will be updated accordingly]	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
17605	5	42	6	2	This is certainly true at global aggregate level but again I think caution in the phrasing. Your own text (p.65) indicates 10 examples of fast transitions (5 from the Sovacool paper, and 5 transitions in energy supply. And that is without mentioning the UK transition. Again – what is the right focus – global aggregate, or national / sectoral exemplars? See also next comment	Taken into account – text revised [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors. The Exec Summary will be updated accordingly]	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
30047	5	42	6	2	Why this paragraph? Is a rather negative way to discuss the speed of transitions. I suggest to delete this paragrpah, as the next one is sufficient and better balanced	Taken into account – text revised [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors. The Exec Summary will be updated accordingly]	Metz	Bert	European Climate Foundation	Netherlands
47493	5	42	6	9	Comparisons with historical energy transitions should consider that those took place spontaneouslly, with more efficient energy sources displacing less efficient ones. The changes expected for mitigation are different, as they do not generally move towards more efficient energy sources, but neither do they need to be spontaneous.	Accepted – text revised [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors. The Exec Summary will be updated accordingly]	Rakonczay	Zoltán	European Commission, Directorate General for Research	Belgium
15675	5	4		5	Are the authors saying that the improvements in emissions intensity reversed after 2011? As written this seems to be what the text says.	accpeted. The sentence will be changed to "After 2011, the emissions declined from intensity improvement outweighed those incresed from trade growth, leading to a net reduction in trade-related CO2 emissions".	Gillett	Nathan	Environment and Climate Change Canada	Canada
45495	5	14		20	Population growth in Asia (China and India), Africa (NIGERIA) and United State of America are stronger drivers of CO2 emissions. Late 2011 and 2014 fossils CO2 emissions has accelerated greatly in larger percentage. Increased in use of coals and gasoline generator sets in Nigeria has speed up. Coal usage in United States of America has speed up the CO2 emissions to Global reduction of CO2 and increased in carbon footprints. Fossils fuel CO2is increasing daily in major oil producing countries. An integrated approach and measures must be put into consideration to monitor by region in fossil fuels CO2 production and monitoring the Carbon footprint. Proper analysis must be implemented, integrated approach and combating system must be implemented inline with the government's agreements to the Paris Agreements.	Taken into account – text revised [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors. The Exec Summary has been updated accordingly]	Adegoke	Abiodun	Samsung electronics West Africa	Nigeria
45497	5	21		27	Despite having lower per capita emissions, developing countries remained major accelerators of Global CO2 emissions growth after 2008.(Roburst evidence). Strongly agreed. The developing countries in Africa, Asia and South America have struggled to cope with the effects and aftermath of Global CO2 emissions. This regions are the strongest and most vulnerable. A proper system modelling and system approach must be implemented in relation to climate change, measures for future trends must be put into consideration to allow the commissions on GHGs sets out techniques inline with the Paris Agreements on Climate change and Land.	Taken into account – text revised [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors. The Exec Summary has been updated accordingly]	Adegoke	Abiodun	Samsung electronics West Africa	Nigeria
45499	5	28		31	The relationship between demographic factors and GHG is extremely complex. Smaller household has larger per-capita carbon footprints, mostlt in developing country. (Extreme poverty in some part of Africa and some other countries has strong contribution to the carbon footprints.	Taken into account – text revised [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors. The Exec Summary has been updated accordingly]	Adegoke	Abiodun	Samsung electronics West Africa	Nigeria

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
45501	5	32		37	Educating extreme poverty and providing universal access to modern energy source and services to populatuonmost especially in Sub-Saharan Africa, can be very complex. Providing sustainable electricity to developing countries jas a long way to go.In context; its a developing issues across country globally. Nigeria are major example of the complex and inadequate, unsustainable, poor environmental quality and greater contributor to environmental issues The population growth is increasing at a fast pace in larger percentage. The reports must be implemented inline with the contribution of developing countries with large population and poor access to basic modern electricity.	Taken into account – text revised [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors. The Exec Summary has been updated accordingly]	Adegoke	Abiodun	Samsung electronics West Africa	Nigeria
19743	5	39		39	Writing 'developed and Asian countries' could be read as implying there are no developed countires in Asia. I suggest 'developed countries and developing countries in Asia' or similar.	Taken into account – text revised [Section 2.4 was completely rewritten with a more consistent evaluation of drivers in regions and sectors. The Exec Summary has been updated accordingly]	Gillett	Nathan	Environment and Climate Change Canada	Canada
45505	5	42		45	Thecspeed of historical energy transitions is insufficient for keeping warming well below (2°C). Meeting thevParis Agreements required advanced technological changes and education.An integrated technology techniques and education in environmental impacts awareness is extremely important and what each countries are doing to meet up the Paris Agreements . High temperature in the tropical region for 2020 is increasing, therefore an increase in rainfalland more flooding both in developed and developing are inevitable. Data analysis from the WMO for 2020 should be monitored to determine the future trends in the global weather extreme and temperature extreme.	Noted. Text now says hsiotrical pace is insuffiicient	Adegoke	Abiodun	Samsung electronics West Africa	Nigeria
46927	5	23			The concept "production-based emissions" is introduced without prior definition. Make clear at first appearance that you use it synonomous with territorial. Territorial seems to be the preferred notion and is also used in the section-titles.	Accepted – text revised	Fæhn	Taran	rerserach institute	Norway
43375	6	7	6	8	The last sentence risks obfuscating the fundamental difference between using CCS for eliminating emissions from fossil and cement plants, versus using CCS along with Bioenergy or Direct Air Capture plants to generate CO2-removal. CO2-removal is a poor if not inappropriate substitute to early retirment of fossil energy infrastructure. Rather CO2-removal is needed independently of the need to retire fossil fuel infrastructure...	Noted and revised	Honegger	Matthias	Perspectives Climate Research gGmbH	Germany
17607	6	5	6	9	Around here I think you need to underline that technology-led transitions tend to occur as an S-curve substitution process, and that with a phase of exponential growth at first, the aggregate indices can be very misleading. See the debate of INET including my response to Papers by Semienuk et al, and Schroder et al, in Grubb (2018) 'Conditional Optimism: Economic Perspectives on Deep Decarbonization' https://www.ineteconomics.org/perspectives/blog/growth-with-decarbonization-is-not-an-oxymoron	Noted. Text now describes the rapid recent growth as an important positve development.	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
30049	6	12	6	14	That is good to know, but what is more important is to note that PV an wind are now cheaper than fossil technologies in most regions (the point being that complaints of high cost of transition are no longer credible)	Noted. We have emphasized this point on costs much more prominently in the SOD	Metz	Bert	European Climate Foundation	Netherlands
36405	6	14	6	15	CCS & BECCS: Is it useful to have abbreviations in executive summary that might be read by non-experts? Also the use of the term 'scalability' and 'scale-up' might not be obvious for many non-experts	Noted. We have tried to define acronyms and include important terms in the glosaary. We now describe scale up more specifically in the SOD.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
34361	6	15	6	15	Add the following sentence: CO2 utilization is becoming an important component of the strategy portfolio necessary for curbing CO2 emissions (with an estimated potential impact of gigatons equivalent CO2 emissions, similar or even superior to the impact of CCS and biofuels, but with a lower cost for society. (e.g. REFERENCES: 1).Ampelli et al., 2015: CO2 utilization: an enabling element to move to a resource and energy-efficient chemical and fuel production, Phil.Trans.R.Soc.A, 373, 2)IEAGHG, 2019a: Putting CO2 to Use – Creating value from emissions, International Energy Agency, 3) CCES, 2019: Carbon Utilization – A vital and effective pathway for decarbonization, Center for Climate and Energy Solutions)	Noted. We describe CCU in the text and while acknowledging its potential importance, focus on its slow adoption to date	Sapart	Célia	Université Libre de Bruxelles et Co2 Value Europe	Belgium
24263	6	10	6	17	Would the authors consider include nuclear power as a source of renewable energy here?	We discuss nuclear power but it is not a form of renewable energy	Zhifu	Mi	University College London	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
46453	6	10	6	17	This is paragraph engages in renewable energy advocacy contradicted by the report later, which admits on page 48, "The strong growth of renewables energy... played a minor role in slowing down emissions growth..." Plus, this report makes no mention of any downsides to solar and wind, which are energy dilute and unreliable. Various studies have shown that the cost of integrating unreliable wind energy is high and rises as more wind is added to the system. For example, in Germany, when wind is 20 percent of electricity, its cost to the grid rises 60 percent. And when wind is 40 percent, its cost rises 100 percent.	Chapter 6 covers the advanategs and disadvantages of soalr wind and other energy technologgies	Shellenberger	Michael	Environmental Progress	United States of America
47495	6	10	6	17	It would be reasonable to split the paragraph into two. Inder the current headline, only the technologies showing the rapid progress should be presented. Another paragrpah should discuss CCS under an appropriate headline.	Noted. We have completely rewritten this section for the SOD	Rakonczay	Zoltán	European Commission, Directorate General for Research	Belgium
14269	6	11	6	17	Addition: ""Similarly, CCU technologies encompass a variety of techologies at different maturity stages, therefore scale-up and replicability is essential for increased impact."	Noted. We have completely rewritten this section for the SOD	Perimenis	Anastasios	CO2 Value Europe (Association) - CCU Offiver	Belgium
36407	6	18	6	18	Unclear '...requires finance..' The term is used meaning different things as it could be the sector or money. Maybe change to 'financial investments'?	Noted. We have completely rewritten this section for the SOD	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
18353	6	18	6	22	"Techonological change requires finance in developing countries and ensuring participation of developing countries requires strong financial and other supports" seems biased. This sentence is based on {2.6.4}, but that section mainly discusses cost reduction in energy technologies and speed of technology adoption.This summary demonstrates the lack of the author's scientific integrity.	We disagree. Technological change in dveeloping countries is not possible with finance.	Hombu	Kazuhiko	Graduate School of Public Policy, The University of Tokyo	Japan
30051	6	18	6	22	The statement is misleading regarding the financial support, because renewable energy is now cheaper in many regions than fossil. Of course there is a need for large investments, but these replace investments in fossil. I think it is critical to make this point very clearly.	Noted. We have emphasized this point on costs much more prominently in the SOD	Metz	Bert	European Climate Foundation	Netherlands
24265	6	18	6	27	It may be useful to mention the importance of private sector involvement in mitigation technology investment. Governmental funding alone is not enough to close the funding gap	Noted. We have completely rewritten this section for the SOD	Zhifu	Mi	University College London	United Kingdom (of Great Britain and Northern Ireland)
25589	6	25	6	27	The sentence starting 'necessary policies involve...' will be interpreteted as policy prescriptive by many policymakers in the SOD review.	Noted. We have completely rewritten this section for the SOD	Connors	Sarah	IPCC WGI TSU	France
26161	6	28	6	28	Not sure there is robust evidence and high agreement about this statement	Rejected. The statement is strongly supported with data discussed in the existing reviewed inequality literature.	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
30053	6	28	6	29	why this statement? It is not an important point I would say. More important is what the emission-income elasticity is and how that is changing over time and in different regions. Unfortunately the current text in 2.4.1 is confusing	Rejected. The trend highlighted in the available literature relates to the reduction of between countries income inequality. The reviewer comments is correct but the studies reviewing do not report on a emission-income elasticity over time or are inconclusive about this relationship. The trends of inequality between and within countries correspond with the observed emissions trajectories this is highlithed in section 2.4.1.	Metz	Bert	European Climate Foundation	Netherlands
26809	6	31	6	31	Explain that this is on a percentage basis, otherwise it does not make sense.	Rejected. The sentence is clear.	Verchot	Louis	International Center for Tropical Agriculture	Colombia
3145	6	34	6	35	The text "36-45% of global GHG emissions" does not align with that shown in line 48 of page 81: "35-45% of global emissions". Please clarify which figure is correct.	Accepted, you are correct, it shold be 35%. thanks for spotting the mistake.	LEE	Sai Ming	Hong Kong Observatory	China
30055	6	34	6	35	This is an important statement, but is this based on consumption based accounting? And is there a difference between high income and other countries?	Rejected. the text is clear. it is consumption-based (line 30) and there are differences between countries (lines 33-35).	Metz	Bert	European Climate Foundation	Netherlands
14557	6	34	6	40	Clarify more clearly in the bold headline statement that this is considering on an individual basis. For example, by saying: The top 10% wealthiest individuals globally contribute to	Accepted. The statement in line 30 should read that "Consumption-based CO2 emissions OF INDIVIDUALS...	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
3147	6	40	6	40	The Section referenced should be 2.7.2 instead of 2.7.1.2.	Accepted	LEE	Sai Ming	Hong Kong Observatory	China

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
10309	6	41	6	42	I did not find clear enough support in the body of this chapter to support this ES statement as written (only one citation, Gough 2017, and it is stated as some "may wish" to emulate lifestyles!?). Even if true this seems to belong much more in chapter 5. Lines 43-44 seem rather obvious - where is the policy-relevant finding?	Accepted. Statement has been reviewed and adjusted to reflect the support found in the literature reviewed. The statements in the inequality subsections in this chapter have been discussed and are aligned with discussions advanced in Chapter 5, they compliment and do not exclude each other. Policy changes may be more difficult to accomodate in scenarios of higher wihtin income inequality, but as inequality is reduced emulation of high carbon footprint lifestyles deters mitigation.	Reisinger	Andy	NZAGRC	New Zealand
14559	6	41	6	42	I found this headline statement not very useful as written. Can this be put in plainer language? What does "emulate" mean in this sentence? How would a person "emulate" a consumption pattern?	Rejected. Synonym is imitate.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
2303	6	41	6	45	I did not understand this section of the summary before reading section 2.7.2. After reading it, I think it is an over-simplification not taking into account the rise of environmental knowledge, evolution of social norms (p81 l16-32), complex inequality-related dynamics (p82 l4 - p83 l5) etc.	Rejected. The summary text refers to economic growth, population and affluence as drivers that are clearly quantified in the literature and assessed as strongest drivers of emissions amongst those evaluated. This does not neglect the relevance of other factors/drivers such as rise of environmental knowledge and evolution of social norms and inequality. For these, however, the available literature has not established a clear quantitative reference between those variables and emissions trends.	Martinerie	Patricia	CNRS	France
35845	6	41	6	45	Such inequality exists not only within countries, but also across countries. Even today, 80% of the population relies on just 20% of the resources, while the 20% of the population still uses 80% of the resources. Nothing has changed, just shifted.	Rejected. Earlier statements of the executive summary have made that point.	Gupta	Himangana	Institute for the Advanced Study of Sustainability, United Nations University, Tokyo	Japan
35727	6		6		Looking at the top 10% of global wealthiest needs to be clear this relates to people and not companies?	Accepted. The statement in line 30 should read that "Consumption-based CO2 emissions OF INDIDUALS...	Hancock	Linda	Centre of Excellence on Electromaterials Science Deakin University	Australia
19745	6	28		33	The net effect of the decreased income inequality between countries on GHG emissions is not clear from this paragraph. The bold headline simply says that inequality has decreased while emissions have increased, without specifying whether there is a causal link between the two. The rest of the paragraph just describes how GHG emissions increase with income in different countries, imploying that economic growth has caused an increase in GHG emissions, but the effect of the change in inequality on emissions is not clear.	Accepted. The inequality vs emissions assessment of the literature is further elaborated. However, it is still inconclusive and it does not establish causality or determine a net effect between trends for reduced income inequality (between and within countries) and the net impact on emissions. There is a net correspondence of reduced between countries inequality with the larger observed trends of strong emissions growth during the same time period,and this is highlighted in the literature and in this section. This topic is of high relevance given the SDGs goal for reducing inequality meaning, this goals needs to be pursued with attentive consideration to the consequences for emissions growth.	Gillett	Nathan	Environment and Climate Change Canada	Canada
19747	6	34		35	It wasn't immediately clear whether this sentence is referring to the top 10% of countries or individuals by emissions. This only becomes clear from reading the whole paragraph. Clarify in the bold sentences.	Accepted, will revise the text.	Gillett	Nathan	Environment and Climate Change Canada	Canada
19749	6	41		42	This text seems to be saying that wealthy consumers, middle-income consumers and low-income consumers all follow carbon-intensive consumption patterns. And that middle-income and low-income consumers only follow these patterns because they are emulating wealth consumers. Is this the correct interpretation?	Accepted. The text has been revised to clarify who the high emitters are by income. The emulation of consumption patterns of high emitters is also highlighted in the literature and discussed not in the ES but within the section.	Gillett	Nathan	Environment and Climate Change Canada	Canada

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
19759	6	41		42	This text seems to be saying that wealthy consumers, middle-income consumers and low-income consumers all follow carbon-intensive consumption patterns. And that middle-income and low-income consumers only follow these patterns because they are emulating wealthy consumers. Is this the correct interpretation?	This comment is redundant (see previous reponse)	Gillett	Nathan	Environment and Climate Change Canada	Canada
17609	6	14			Here I suggest to include: "Growth rates of wind, PV and electric vehicles over the past decade have been X, Y, Z% respectively; another decade at such % growth rates would mean they contribute A, B, C of electricity and vehicle fleet respectively" You might be surprised at the result …	Noted. We report the grwoth rates in the main text	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
17611	6	27			Some reference here to wide economic drivers including price and market-pull developments. Also somewhere the macro context and evidence around costs – see my remark to section 2.4 on long-run "energy cost constancy" as countries responded differently to energy price shocks	We now make this point in the statement that begins "Robust incentives "	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
10307	6	34			The expression "the top 10% emitters (the global wealthiest 10% on a per capita basis)" doesn't make sense to me - these two are not necessarily the same? Is this conveying a finding (the top 10 emitters are the wealthiest?) - in which case, this is a finding in its own right.	Accepted,. It should read the global 10% in terms of income rather than emitters.	Reisinger	Andy	NZAGRC	New Zealand
17613	6	34			IS this saying the top 10 emitters are also the top 10 wealthiest – absolute, or per-capita, in each case? And/or the wealthiest 10% of the global population, irrespective of countries? Some analysis of contributions of individuals by wealth – irrespective of country - is indeed welcome.	Accepted,. It should read the global 10% in terms of income rather than emitters. And, yes, it is global income categories irrespective of country	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
36409	7	2	7	3	'… early retirement..' of what?	Rejected. We do not talk about early retirmement. The text refers to the assumptions around retirment ages and capacity utilisation. We tried to clarify this.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
3149	7	4	7	4	The figures "660", "720" and "[460-910]" are different from those in the main text, line 9-10 of page 87, which are likely extracted directly from the references and are more precise. Please harmonize the presentation of figures.	We harmonised everything	LEE	Sai Ming	Hong Kong Observatory	China
3151	7	5	7	5	The figures "850 (600-1100)" are different from those in the main text, line 13-14 of page 90, which are likely extracted directly from the reference and are more precise. Please harmonize the presentation of figures.	We harmonised everything	LEE	Sai Ming	Hong Kong Observatory	China
14561	7	1	7	8	"By far" is a bit emotive and not very precise. With the latest remaining carbon budget for 1.5°C now available in IPCC WG1 SOD (390 GtCO2, 50th percentile, from 2020 onwards), one can simply say: Without early retirement of fossil fuel infrastructure, future CO2 emissions commited by the operation of current energy infrastructures would already be twice the remaining carbon budget for keeping warming below 1.5°C.	Accepted in principle, but we adjusted the language differently.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
34363	7	6	7	8	Please rephrase: Hence, keeping warming below 1.5°C will include early retirement of fossil energy infrastructures, fast Carbon Capture Utilisation and/or storage deployment and direct removal of CO2 from the atmosphere (e.g. BECCS, DAC).	Accepted	Sapart	Célia	Université Libre de Bruxelles et Co2 Value Europe	Belgium
30057	7	7	7	8	This is a more important statement than the current headline of the paragraph	Rejected. In principle, I can see the point, but this is not perceived core remit of the chapter.	Metz	Bert	European Climate Foundation	Netherlands
30443	7	7	7	8	Not clear why CCS is mentioned, but not RE, in needed transformation. If RE in inlcuded in the equation, please state clearly for policy makers.	Retirement of fossil fuel infrastructure implies alternatives such as renewables. But we want to emphasize how committed emissions have to be addressed - this is the reason for the focus.	Cook	Lindsey	Quaker United Nations Office / Friends World Committee for Consultation (IPCC Observer)	Germany
41059	7	9	7	9	the sentence "Future committed…." is unclear to me. How can you say that something in the future "have" failed to peak. Please consider reformualtion.	We tried to rephrase more clearly	Fuglestvedt	Jan	CICERO	Norway
15921	7	10	7	10	Typo on carbon „saved", changed to carbon saved	Noted	Takarina	Noverita	Universitas Indonesia	Indonesia
30059	7	10	7	11	This is a much better headline of the paragraph, bringing the message home more clearly	Accepted	Metz	Bert	European Climate Foundation	Netherlands

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
17619	7	14	7	16	I think around there should be a reference to the governance dimension. Two key observations / references: As a driver, It surely is relevant to note that countries which had accepted legally binding targets under the Kyoto Protocol all complied: Shishlov, I., Morel, R., Bellassen, V. 2016. Compliance of the Parties to the Kyoto Protocol in the first commitment period. Climate Policy. doi:10.1080/14693062.2016.1164658 This evidence was not available for AR5 (compliance was only reported in 2014 and verified in 2015). I also commented on this in an extended Editorial, which pointed to evidence that this was not because the targets were too easy and didn't require substantive action (Michael Grubb (2016) Full legal compliance with the Kyoto Protocol's first commitment period – some lessons, Climate Policy, 16:6, 673-681, DOI: 10.1080/14693062.2016.1194005 It is striking in fact that 17 of the 18 countries for which you report "sustained emission reductions" (Fig 2.6) were industrialised country Parties to the Kyoto protocol, with legally binding emission reduction commitments, which they delivered. For a chapter entitled "emission trends and drivers" it seems very strange not to mention this as a likely major driver. Second, I think the wider spread of climate legislation as the pressures grew to globalize efforts also should feature more strongly: Gabriela Iacobuta, Navroz K. Dubash, Prabhat Upadhyaya, Mekdelawit Deribe & Niklas Höhne (2018) National climate change mitigation legislation, strategy and targets: a global update, Climate Policy, 18:9, 1114-1132, DOI: 10.1080/14693062.2018.1489772	Rejected. This is for the policy and sector chapters.#	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
30061	7	14	7	16	Better move this into the previous paragraph, where it illustrates that the problem is still growing; keeping it separate gives too much of a rosy picture	Rejected. As the finding do not directly point to the same bits of the data.	Metz	Bert	European Climate Foundation	Netherlands
18355	7	17	7	18	There is very poor evidence in {2.9} to conclude "Emissions reduction has taken place as a result of carbon pricing associated with carbon taxes or emissions trading." Without verifying the impacts of economic downturn, other policies such as FIT, cost reductions of technologies, and fuel prices decreases, and without konwing their relative impacts to the emission, it is difficult to identify the causes of emissions reduction. See ;Ball, Jeffrey. "Why Carbon Pricing Isn't Working: Good Idea in Theory, Failing in Practice." Foreign Aff. 97 (2018): 134.	Noted. Though there are literatures against the effectivenss of carbon pricing, I found a broad agreement on the impacts of carbon pricing.	Hombu	Kazuhiko	Graduate School of Public Policy, The University of Tokyo	Japan
30063	7	17	7	18	"Emissions reduction" is not the right word: emissions are still rising in most constituencies, but less so when carbon prices are higher. By the way ,do not use a complicated term like "carbon pricing gap"	Taken into account. The choice of words will be considered again after the review of SOD, with gathering more opinions from experts and governments.	Metz	Bert	European Climate Foundation	Netherlands
35611	7	20	7	20	Please explain what "carbon pricing gap" means or use another phrase.	Taken into account. The choice of words will be considered again after the review of SOD, with gathering more opinions from experts and governments.	Finnveden	Göran	KTH Royal Institute of Technology	Sweden
10311	7	17	7	23	It would be immensely useful to have a clearer picture to what extent the acceleration of technology (as per p6l10-17) has taken place as a result of climate policies. I.e. don't focus only on actual emissions reductions, but also on the extent to which climate policy has accelerated technological progress (which may not yet have resulted fully in actual emissions reductions). This would be highly relevant to clarify the debate about RCP8.5 as a scenario, and the extent to which the fact that 'business-as-usual' projections now lie well below the RCP8.5 trajectory is because climate policy has been effective in shifting technology costs that will change emissions even in the absence of any carbon pricing.	Noted. Literature review on technology is provided in the main text. It seems to be premature to provide a clear picure at this stage with limited evidence.	Reisinger	Andy	NZAGRC	New Zealand
19751	7	1		2	The meaning of 'Future CO2 emissions committed from current energy infrastrcuture' may not be clear to all readers. Suggest re-phrasing along the lines of 'Continuing to use existing energy infrastructure for its expected lifetime will lead to CO2 emissoins which exeed the remaining carbon budget....' or similar.	Noted. We have tried to formulate clearer now.	Gillett	Nathan	Environment and Climate Change Canada	Canada
19755	7	15		16	Does 'Proposals to bulid coal power plants were roughly stable' mean that a fixed number of coal plants were proposed in 2009, and no net additional power plants were proposed? Or is this referring to the rolling number of plants proposed i.e. the same number of new plants were proposed in 2009 as 2010 and 2011 etc.? Also are the power figures on line 16 the total proposed power, or are these the proposed new capacity per year?	Noted. We tried to clarify the language.	Gillett	Nathan	Environment and Climate Change Canada	Canada

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
19761	7	15		16	Does 'Proposals to bulid coal power plants were roughly stable' mean that a fixed number of coal plants were proposed in 2009, and no net additional power plants were proposed? Or is this referring to the number of plants proposed per year i.e. the same number of new plants were proposed in 2009 as 2010 and 2011 etc.? Also are the power figures on line 16 the total proposed power, or are these the proposed new capacity per year?	Note. We tried to clarify the language.	Gillett	Nathan	Environment and Climate Change Canada	Canada
43919	7	21		23	Cause and effect understanding if available would be much needed in anhancing confidence in the relationship between carbon pricing and emissions reduction.	Noted. The sentence has been changed.	and Elvira Poloczanska	Hans Poertner	Alfred-Wegener-Institut	Germany
17615	7	1			Some relevant IPCC Authors had an email exchange about the use of this word (21 – 23 Oct 2019) The OED definition of “committed” is “Pledged or bound to a certain course or policy; dedicated.” The word here is used in an entirely different way, to simply mean “the emissions associated if an asset is used to its expected or planned lifetime, and at the expected utilization level”. The email exchange noted several problems in equating this with “committed”. Most obviously, there are plenty of examples of ‘committed’ capital not actually being utilized because something better displaced it – indeed that is entirely what the Schumpeterian. The most obvious recent example is coal in the US and Europe, where a lot of “committed” coal plant has turned out to be redundant and closed prematurley. A proposed term in the email exchange was “carbon-capital at risk” See also my comments on the section.	Noted. We tried to avoid the use of the phrase committed emissions at least at the level of the summaries.	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
19753	7	6			Say what fraction of the 2C budget these emissions correspond to.	Rejected. Different ways of showing things.	Gillett	Nathan	Environment and Climate Change Canada	Canada
17617	7	11			I would suggest to add, that (using the European and US examples), an observation relating to the acceleration in the stranding, under-utilisation and collapsed value of coal assets in Europe and US. See also my comment in this section. This would also link to the subsequent point.	Rejected. This is nothing we cover in the chapter.	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
17621	7	18			And complementary polices of energy efificency and the growth of alternative energy sources. For a detailed account of the most dramatic case – the demise of UK coal – see Grubb M. and D.Newbery (2018), UK Electricity Market Reform and the Energy Transition: Emerging Lessons, Energy Journal, Vol. 39, No.6, DOI: 10.5547/01956574.39.6.mgru	Accepted. Renewable energy policies are specified as an effective policy instrument. Grubb and Newbery (2018) has been referred in the main text and the UK case of electricity market reform has been highlighted through a dedicated box.	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
41063	8	2	8	4	Here you may add a reference to WGI. Please get in touch with relevant authors there.	Accepted, added.	Fuglestvedt	Jan	CICERO	Norway
24811	8	18	8	18	Delete "and carbon lock-in."	Rejected, a widely used term, relevant to the discussion in Section 2.8.	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
15751	8	19	8	21	Figure 2.1 needs improvement, drivers are mixed up with leverage points. Categories in each circle are not easily understood. Perhaps some thought should be given to conceptualize drivers and leverage points, perhaps a graph based on arrows of causality and of feeback, for example a Causal Loop Diagram.	Figure deleted, replaced with a chapter roadmap.	FRACASSI	EDUARDO PEDRO	ITBA Instituto Tecnologico de Buenos Aires	Argentina
2893	8	20	8	21	In Figure 2.1 "Policies" to amend as "Policies and measures"; "Technological change and innovation" to amend as "Technological change, innovation and transfer".	Figure deleted, replaced with a chapter roadmap.	Pyrozhenko	Yurii	IPCC TFI TSU	Japan
2305	8	21	8	21	I would replace "fuel choice" with fuel and land-use choice ; "cooperation" with competition | cooperation ; and mention investment in the third circle from center	Figure deleted, replaced with a chapter roadmap.	Martinerie	Patricia	CNRS	France
47497	8	20	8	22	Figure is not informative and has no added value.	Figure deleted, replaced with a chapter roadmap.	Rakonczay	Zoltán	European Commission, Directorate General for Research	Belgium
16699	8	22	8	22	The connection between section 3.4 and other sections is not quite clear.	Figure deleted, replaced with a chapter roadmap.	Ma	Leiming	Shanghai Central Meteorological Observatory	China

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36411	8	22	8	22	Caption for figure is very unclear as I) there are no linkages shown ii) it says 'emission trends' but the inner circle says 'emission drivers'. Iii) not trends are shown. Generally what is shown here are drivers for GHG from the different (social/political/institutional) sectors . The text below the caption much more clearly describes its contents. Consider changing wording in caption	Figure deleted, replaced with a chapter roadmap.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
30445	8	23	8	23	This is a really interesting visual, helpful, and excellent to see consumption and trade getting greater focus than in the AR5. Yet wanted to check - is it meant to be covering only some drivers, not all? Will it be next to a visual giving a breakdown of specifics, as in the AR5 synthesis report - Human activities include fossil fuel extraction and combustion, black carbon (i.e.: soot, the incomplete combustion of fossilfuels, biofuel and biomass), deforestation and forest degradation, intensive and animal agriculture, industry, transport, buildings and, increasingly, hydrofluorocarbons...	Figure deleted, replaced with a chapter roadmap.	Cook	Lindsey	Quaker United Nations Office / Friends World Committee for Consultation (IPCC Observer)	Germany
32191	8	24	8	24	Change from 'provides one way of conceptualizing drivers' to 'provides a scematic representation of linkages between emission drivers'	Figure deleted, replaced with a chapter roadmap.	DUBE	LOKESH CHANDRA	NATCOM Cell, Ministry of Environment, Forest and Climate Change, Government of India	India
15925	8	24	8	25	The general conceptualising drivers should be updated and incorporated the current global pandemic as the potential drivers. While, why use the term territorial? Is it already including the terrestrial and aquatic emissions?	Figure deleted, replaced with a chapter roadmap.	Takarina	Noverita	Universitas Indonesia	Indonesia
35847	8		8		Figure 2.1: Are the rings arranged in the order of importance of the drivers "immediate and underlying"? If yes, I belive policies are an important driver as compared to demography. A highly populated economy could have lower emissions than a less populated one. It also depends on the level of "development", which is a driver in itself. This figure does not show linkages. The figure can be improved since the storyline of the chapter relies on this.	Figure deleted, replaced with a chapter roadmap.	Gupta	Himangana	Institute for the Advanced Study of Sustainability, United Nations University, Tokyo	Japan
16195	8	20	9	2	Consider adding "military" or something similar to the figure and its description. Global military contributions to GHG emissions are significant, and including them will help to build the necessary awareness to bring change. Currently consumers have no control over military emissions, so including them is important.	Figure deleted, replaced with a chapter roadmap.	Helman	Daniel	College of Micronesia-FSM	Micronesia, Federated States of
1267	8	4		5	There is need to show such literatures. It will serve as a reference and quantify the statement in line 4-line 6	Accepted, This is exactly why references are included.	Anoruo	Chukwuma	University of Nigeria, Nsukka	Nigeria
45661	8	2		7	The GHG concentration in the atmosphere and the annual anthropogenic GHG emissions continue to grow and have historical high. why? Most Oil producing countries are doing less in the GHGs inventory most especially developing country like Nigeria. The comission on GHGs inventory are not doing what is expected of them. They dwell on false reports, paper works from nations thatvare not properly formulated or checked which are not inline with the Paris Agreements. Strongly recommend an integrated and comprehensive approach to GHG emissions with System modelling inline with the Paris Agreements in relation to climate change.	Rejected. This is beyond the mandate and scope of this chapter.	Adegoke	Abiodun	Samsung electronics West Africa	Nigeria
10313	8	1			The introduction is wordy. This is fine for a FOD, but the next draft should more concisely set out what the chapter actually delivers, rather than what it aspires to deliver.	Accepted, text revised.	Reisinger	Andy	NZAGRC	New Zealand
28341	8	22			How about polical interest?	Noted. Political interests manifest themselves through policies.	Chan	Hoy Yen	ASEAN Centre for Energy	Malaysia
14363	8				2.1 is not effective at showing linkages	Figure deleted, replaced with a chapter roadmap.	Bradshaw	Michael	University of Warwick	United Kingdom (of Great Britain and Northern Ireland)
24235	9	36	9	37	"(2.8.2) ", and "(2.8.3)" should be revised as "(Section 2.8.2)", and "(Section 2.8.3)".	Accepted but this part is deleted.	Zhifu	Mi	University College London	United Kingdom (of Great Britain and Northern Ireland)
15927	10	9	9	10	Typo on N_2O (the 2 should be subscript)	accepted	Takarina	Noverita	Universitas Indonesia	Indonesia
36413	10	1	10	1	Not sure the term 'territorial' is a good choice for understanding. I guess the term is used as opposite to 'global'? So why not use more established terms as 'regional' or 'national' instead?	Rejected. Territorial emission accounting is an established concept. We better clarify the terminology in the introduction.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
32385	10	2	10	7	While not GHGs, black and brown carbon aerosols also are important climate forcers and comes from some similar sources that should be considered part of this discussion. While organic carbon is reflective, the warming effect of black and brown carbon components overall amplify warming. Black carbon is a powerful climate-warming aerosol that directly warms the atmosphere by absorbing solar radiation and indirectly by darkening snow and ice surfaces. Nearly 90% of black carbon emissions come from residential solid fuels, diesel engines, and residential coal; the rest of the emissions come from aviation, shipping, and flaring. Reducing black carbon is especially beneficial for the Arctic because black carbon not only warms the atmosphere but also facilitates additional warming. Once black carbon is deposited on the snow and ice, it reduces the reflectivity (albedo) and absorbs extra solar radiation, which leads to further melting than pristine snow and ice. Since 1890, black carbon has contributed about 0.5–1.4 ºC of warming to the Arctic. Bond T. C., et al. (2013) Bounding the role of black carbon in the climate system: A scientific assessment, J. GEOPHYSICAL RESEARCH–ATMOSPHERES 118(11):5380–5552; Myhre G., et al. (2013) CHAPTER 8: ANTHROPOGENIC AND NATURAL RADIATIVE FORCING, in IPCC (2013) CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS, Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Table 8.A.6; Qian Y., et al. (2014) Light-absorbing Particles in Snow and Ice: Measurement and Modeling of Climatic and Hydrological impact, ADVANCES IN ATMOSPHERIC SCIENCES 32:64–91; Arctic Monitoring and Assessment Programme (AMAP) (2017) ADAPTATION ACTIONS FOR A CHANGING ARCTIC: PERSPECTIVES FROM THE BARENTS AREA; International Energy Agency (IEA) (2016) WORLD ENERGY OUTLOOK SPECIAL REPORT: ENERGY AND AIR POLLUTION; World Bank & International Cryosphere Climate Initiative (2013) ON THIN ICE: HOW CUTTING POLLUTION CAN SLOW WARMING AND SAVE LIVES.; Shindell D. & Faluvegi G. (2009) Climate response to regional radiative forcing during the twentieth century, Nature Geoscience 2:294–300; Feng Y., et al. (2013) Brown carbon: a significant atmospheric absorber of solar radiation?, ATMOS. CHEM. PHYSICS 13:8607–8621.	Noted. The chapter will continue to focus on Co2, ch4, n20 and f-gases, but we have added a section on short-lived climate forcers.	Zaelke	Durwood	Institute for Governance & Sustainable Development	United States of America
32763	10	2	10	7	While not a GHG, black carbon is also an important influence on warming and comes from some similar sources that should be considered part of this discussion. Black carbon is a powerful climate-warming aerosol that directly warms the atmosphere by absorbing solar radiation and indirectly by darkening snow and ice surfaces. Nearly 90% of black carbon emissions come from residential solid fuels, diesel engines, and residential coal; the rest of the emissions come from aviation, shipping, and flaring. Reducing black carbon is especially beneficial for the Arctic because black carbon not only warms the atmosphere but also facilitates additional warming. Once black carbon is deposited on the snow and ice, it reduces the reflectivity (albedo) and absorbs extra solar radiation, which leads to further melting than pristine snow and ice. Since 1890, black carbon has contributed about 0.5–1.4 ºC of warming to the Arctic. Bond T. C., et al. (2013) Bounding the role of black carbon in the climate system: A scientific assessment, J. GEOPHYSICAL RESEARCH–ATMOSPHERES 118(11):5380–5552; Myhre G., et al. (2013) CHAPTER 8: ANTHROPOGENIC AND NATURAL RADIATIVE FORCING, in IPCC (2013) CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS, Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Table 8.A.6; Qian Y., et al. (2014) Light-absorbing Particles in Snow and Ice: Measurement and Modeling of Climatic and Hydrological impact, ADVANCES IN ATMOSPHERIC SCIENCES 32:64–91; Arctic Monitoring and Assessment Programme (AMAP) (2017) ADAPTATION ACTIONS FOR A CHANGING ARCTIC: PERSPECTIVES FROM THE BARENTS AREA; International Energy Agency (IEA) (2016) WORLD ENERGY OUTLOOK SPECIAL REPORT: ENERGY AND AIR POLLUTION; World Bank & International Cryosphere Climate Initiative (2013) ON THIN ICE: HOW CUTTING POLLUTION CAN SLOW WARMING AND SAVE LIVES.; Shindell D. & Faluvegi G. (2009) Climate response to regional radiative forcing during the twentieth century, Nature Geoscience 2:294–300.	Noted. The chapter will continue to focus on Co2, ch4, n20 and f-gases, but we have added a section on short-lived climate forcers.	Campbell	Kristin	Institute for Governance & Sustainable Development	United States of America
41065	10	6	10	7	Regarding emissions trends: Please contact WGI TSU for help with referring to WGI here.	Noted	Fuglestvedt	Jan	CICERO	Norway
36415	10	7	10	7	Collins et al → year missing	Accepted and changed	Fetzer	Ingo	Stockholm Resilience Centre	Sweden

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2587	10	8	10	8	...estimated uncertainty ranges for GHGs range from relatively low for fossil fuel CO2 (± 8 %), to intermediate values for CH4 and the F-gases (± 20 %), Comment: much of the uncertainty in the emissions of CF4 has been resolved by the identification of rare earth smelting being an additional source of emission of this gas, reference 2019 IPCC GHG Guidance document, Volume 3 https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/	Noted. We have revamped the section and added a comprehensive assessment on CH4 - in line with the uncertainty assessment of the methane budget by the Global Carbon Project - the most comprehensive assessment to date.	Czerniak	Michael	Atlas Copco - Edwards	United Kingdom (of Great Britain and Northern Ireland)
26811	10	9	10	9	60% for N2O is high. More comments on this below.	Noted. We have revamped the section and added a comprehensive assessment on CH4 - in line with the uncertainty assessment of the methane budget by the Global Carbon Project - the most comprehensive assessment to date.	Verchot	Louis	International Center for Tropical Agriculture	Colombia
47499	10	9	10	9	The uncertainty for "CO2 from FOLU (50%)" is is missing the "+/-" sign. It should be inserted or its absence explained.	Accepted and changed	Rakonczay	Zoltán	European Commission, Directorate General for Research	Belgium
30447	10	1	10	10	This talks about uncertainty percentage ranges, but policy makers will want to see % of each sectors' contribution - would you have a clear diagram here, as in the AR5? In some paragraphs later you give a % for FF, but again, having perspective on the different sector contributors is really helpful for policy makers, and missing here.	Accepted. We added such a diagram.	Cook	Lindsey	Quaker United Nations Office / Friends World Committee for Consultation (IPCC Observer)	Germany
41067	10	10	10	10	This overall uncertainty range for GHG seems arbitrary the way it is presented now (even with a reference). Would be useful to hear more about basis for this. Is it for the aggregated GHGs in terms fo CO2eq ? Then you should in principle include uncertainties in GWP.	Noted. We have extended the discussion by including some recent references of uncertainty analyses.	Fuglestvedt	Jan	CICERO	Norway
47635	10	11	10	13	need to specify GWP - 100 AR5 without feedbacks	Accepted and changed	Slade	raphael	Imperial College	United Kingdom (of Great Britain and Northern Ireland)
2171	10	13	10	13	After the last bullet, I recommend to add a new bullet saying "Uncertainties with regard to the cement sector emissions, in most of the models, arise when they do not take into account the carbon dioxide uptake by mortars and concrete (Sanjuán et al 2020)." Sanjuán, M.Á.; Andrade, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake by Cement-Based Materials: A Spanish Case Study. Appl. Sci. 2020, 10, 339. https://doi.org/10.3390/app10010339	Rejected. Cement emissions are discussed later in Box 1	Sanjuán	Miguel Angel	Technical University of Madrid	Spain
41069	10	13	10	13	Important to make it clear that you mean WGIII here. (Not WGI)	Accepted and changed	Fuglestvedt	Jan	CICERO	Norway
24237	10	15	10	17	Definition of acronyms should appear at their first appearance (e.g., UNFCCC).	Accepted and changed	Zhifu	Mi	University College London	United Kingdom (of Great Britain and Northern Ireland)
24821	10	16	10	17	Delete "and common reporting … AR4 values"	Accepted and changed	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
41071	10	18	10	18	Please add "change" after "Temperature"	Accepted and changed	Fuglestvedt	Jan	CICERO	Norway
26813	10	19	10	19	Consensus used twice	Accepted and changed	Verchot	Louis	International Center for Tropical Agriculture	Colombia
41073	10	19	10	19	"In fact" seems odd.	Accepted. Phrase deleted	Fuglestvedt	Jan	CICERO	Norway
10315	10	11	10	22	This para, if kept here, could be shortened but importantly include a cross-reference to the cross-chapter box on GHG metrics (if the box is kept in its current form). Importantly, Forster et al provide only a WGI perspective on metrics, whereas this chapter (the cross-cutting box) provides a GHG perspective on GHG metrics. It might make sense though to present the key conclusions from that box here in the main text, including not just to explain THAT but justify WHY the WGIII report continues to use GWP100 to aggregate emissions where such aggregation is policy relevant (given that some stakeholders believe this metric is fundamentally wrong/beside the point).	Noted	Reisinger	Andy	NZAGRC	New Zealand
27513	10	11	10	22	The IPCC expert meeting on SLCFs recommended that SLCFs should not be combined with the LLGHGs into a single CO2-equivalent, but rather should be reported separately.	Noted. WGIII had a large consultation among authors and leadership on this topic. We will report gases wherever possible, but provide aggregations into CO2eq where necessary given the multiple relevant dimensions such as sectors, regions, gases etc..	Collins	William	University of Reading	United Kingdom (of Great Britain and Northern Ireland)
41075	10	22	10	22	You may add a reference to the box on metrics	Accepted and changed	Fuglestvedt	Jan	CICERO	Norway

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24473	10	4	10	25	It seems that AR6 is creating a new terminology. If so, there should be clarification on similar but different terms: LULUCF, AFOLU, and FOLU. It will lead to complication in NDC commitment in terms of sector differentiation conflict. Creating new word or terminology should be avoided without critical requirement.	Accepted. We now clarify major concepts in the introduction.	WIN	SAN	Environmental Conservation Department, Ministry of Natural Resources and Environmental Conservation	Myanmar
47501	10	25	10	27	The two bookeeping models may be a reasonable proxy for "FOLU" for the lack of a better estimate, but the limitations of this choice should be acknowledged. These represent mostly land-use changes and do not include all relevant LULUCF fluxes, in particular when it comes to the nexus with bioenergy. Instead of referring to "FOLU", it would be more appropriate to refer to "land-use change" emissions, as done in Box 2.1. In any event, the text should be harmonised with respect to land use, both in terms of the terminology used ("FOLU" vs LUC") and contents (meaning of numbers presented).	Noted. We clarify terminology and concepts at the start of the section.	Rakonczay	Zoltán	European Commission, Directorate General for Research	Belgium
15929	10	23	10	30	In this report you are using EDGAR as your preference. Hence please provide a table to compare the EDGAR with at least 2 other emission database systems. So the reader can see the advantages/disadvantages among those systems.	Noted. Such a comparison is provided in Box 2.1. We clarify this in introductory note.	Takarina	Noverita	Universitas Indonesia	Indonesia
41077	10	40	10	40	I suggest removing the first sentence. You can simply say that CO2 is the dominating driver of human induced climate change.	Noted. Matter of taste.	Fuglestvedt	Jan	CICERO	Norway
14567	10	40	10	42	Cross-reference this with IPCC AR6 WG1, Chapter 7 or with statements higher up in AR6 WG1 TS or SPM.	Accepted. Added cross-references to WG1.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
26163	10	40	10	42	Figures for emissions from industrial processes if available (fossil fuel oxidation, carbonate decomposition) might be very useful	We report the most detailed process emissions available from EDGAR in Figure 2-9, condensed to those with rapid or large absolute growth.	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
2169	10	43	10	43	After "...databases and briefly compare their estimates.", I recommend to add "However, it should highlighted that most of the models do not take into account the carbon dioxide uptake by mortars and concretes (Sanjuán et al 2020)." Sanjuán, M.Á.; Andrade, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake by Cement-Based Materials: A Spanish Case Study. Appl. Sci. 2020, 10, 339. https://doi.org/10.3390/app10010339	Accepted. We have added some text on cement as a carbon sink including recent estimates by the Global Carbon Budget 2020-	Sanjuán	Miguel Angel	Technical University of Madrid	Spain
14565	10	32	14	6	Very nice box and schematics.	Thanks	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
47503	10	32	14	6	Box 2.1: The useful summary should make explicit reference to the treatment of bioenergy. It is not included in the CO2 emissions from energy, but not mentioned under land use either. Whilst past bioenergy use was mostly based on residues (and thus had little impact on LULUCF), bioenergy use is increasingly driven by policies and towards the use of dedicated crops and/or forest harvest. This is not reflected in the energy data at all, but may appear in LULUCF (with some delay and without specific attribution).	We inserted some language that net emissions from bioenergy are covered by AFOLU accounts.	Rakonczay	Zoltán	European Commission, Directorate General for Research	Belgium
12651	10	9		9	higher values for N2O (± 60 %) and CO2 from FOLU (LULUCF) (50%). In accordance with AR5, we use an	Noted	Özdemir	Eray	General directorate of Forestry	Turkey
1269	10	11		22	This paragraph talks so well on converting other greenhouse gases into common units of CO2, but fail to give brief hints about the method of conversion	Rejected. There is an entire box on this as well as a reference to WG1. We have added a reference to the bix.	Anoruo	Chukwuma	University of Nigeria, Nsukka	Nigeria
14365	10	1			Will there be time to discuss the impact of the Coronavirus on global emissions in 2020, see impact on China.	Accepted. We have added some text of the impact of the COVID-19 lockdown on global emissions.	Bradshaw	Michael	University of Warwick	United Kingdom (of Great Britain and Northern Ireland)
47637	10	7			uncertainty range for " GHG emissions"	Noted	Slade	raphael	Imperial College	United Kingdom (of Great Britain and Northern Ireland)
47639	10	34			Box 2.1 - could this be moved to annex B? It is essentially methods related	Rejected. The uncertainty assessment is a core piece of the chapter. Rather than shifting the content to Annex B, we turned the box into a section.	Slade	raphael	Imperial College	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
12489	11	1	11	1	Please, add: "It should be mentioned that most of the models do not take into account the carbon dioxide uptake by mortars and concretes (Sanjuán et al 2020; Xi et al 2016)." Sanjuán, M.Á.; Andrade, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake by Cement-Based Materials: A Spanish Case Study. Appl. Sci. 2020, 10, 339. https://doi.org/10.3390/app10010339 Xi, F.; Davis, S.J.; Ciais, P.; Crawford-Brown, D.; Guan, D.; Pade, C.; Shi, T.; Syddall, M.; Lv, J.; Ji, L.; et al. Substantial global carbon uptake by cement carbonation. Nat. Geosci. 2016, 9, 880–883. https://doi.org/10.1038/NGEO2840	Rejected, but we will address this in the uncertainty section.	PEDRO	MORA PERIS	Profesor Titular de Universidad de la ETSI Minas y Energía de la Universidad Politécnica de Madrid	Spain
2307	12	1	12	1	Box 2.1 Fig 2: I did not find the definition of IPPU	Accepted - defined	Martinerie	Patricia	CNRS	France
38349	12	1	12	1	Box 2.1, Figure 2 includes the acronym IPPU. This needs to be defined (written out) somewhere so that the reader knows what it means.	Accepted - defined	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
14569	12	1	12	17	For completeness both figure and tables should include all datasets included in the overview of figure 1. I noticed PRIMAP-hist is missing, but haven't checked very closely for any further datasets that would be missing.	Broadly accepted, but we do not cover purely synthetic dataset such as CAIT.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
38351	12	14	12	17	Box 2.1, Table 1 has a column labeled "includes cement". Does this mean that the process (non-energy) CO2 emissions from cement production are included? I recommend adding a footnote to clarify what this column means.	Accepted. Added.	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
2899	12	16	12	17	In Table 1 "Uses IPCC emission factors" to amend as: "Uses IPCC default emission factors".	Accepted. Added	Pyrozhenko	Yurii	IPCC TFI TSU	Japan
15931	13	13	13	13	Regarding the uncertainties in energy data in developing countries, please elaborate this. You can provide examples of 5 developing countries and describe the cause of uncertainties in energy data in those countries.	Broadly accepted. We inclide some country examples.	Takarina	Noverita	Universitas Indonesia	Indonesia
24823	13	16	13	16	Delete "extent"	Accepted.	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
16199	13	4	13	34	Consider adding a brief treatment of the uncertainty arising from military usage of FFI to this set of bullet points for clarity.	Rejected.	Helman	Daniel	College of Micronesia-FSM	Micronesia, Federated States of
12491	13	34	13	34	Please, add a new bullet: " - Uncertainties with regard to the cement sector emissions, in most of the models, arise when they do not take into account the carbon dioxide uptake by mortars and concrete (Sanjuán et al 2020; Xi et al 2016)." Sanjuán, M.Á.; Andrade, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake by Cement-Based Materials: A Spanish Case Study. Appl. Sci. 2020, 10, 339. https://doi.org/10.3390/app10010339 Xi, F.; Davis, S.J.; Ciais, P.; Crawford-Brown, D.; Guan, D.; Pade, C.; Shi, T.; Syddall, M.; Lv, J.; Ji, L.; et al. Substantial global carbon uptake by cement carbonation. Nat. Geosci. 2016, 9, 880–883. https://doi.org/10.1038/NGEO2840	Accepted. Discuss with uncertainties lot.	PEDRO	MORA PERIS	Profesor Titular de Universidad de la ETSI Minas y Energía de la Universidad Politécnica de Madrid	Spain
20737	13	34	13	34	After the last bullet, I recommend to add a new bullet saying "Uncertainties with regard to the cement sector emissions, in most of the models, arise when they do not take into account the carbon dioxide uptake by mortars and concrete (Sanjuán et al 2020)." Sanjuán, M.Á.; Andrade, C.; Mora, P.; Zaragoza, A. Carbon Dioxide Uptake by Cement-Based Materials: A Spanish Case Study. Appl. Sci. 2020, 10, 339. https://doi.org/10.3390/app10010339	Accepted, Discuss with uncertainties lot.#	Sanjuán	Miguel Angel	Technical University of Madrid	Spain
26815	13	42	13	43	It is not clear why you are focusing specifically on N2O from FOLU here, it is a tiny emission (0.09Gt CO2e y-1). The important emission is agriculture or AFOLU, not FOLU. Note the assessed uncertainty of FAOSTAT (Tubiello 2015) for this source is 30% and in the SRCCL report we used that value because EDGAR and USEPA also use country data to derive estimates. Unless there is a good justification, I suggest this report remain consistet with SRCCL.	Rejected. We do not focus on N2O from FOLU. We made sure that the language is clear.	Verchot	Louis	International Center for Tropical Agriculture	Colombia
10317	13	41	13	44	It would be useful to have some justification for those uncertainty magnitudes - it's fine to say that this is what you use, but where is your assessment that these uncertainties are the ones you should use? Has nothing changed since the AR5 (if so, say so).	Accepted. Discussions of uncertainties from FOLU CO2 as well as non-CO2 GHGs was not developed. We have now added substantive treatments in line with WG1. We will conclude on uncertainty expert judgements.	Reisinger	Andy	NZAGRC	New Zealand
24825	14	2	14	2	Delete "from FFI which is one reason"	Accepted.	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria

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41081	14	11	14	11	The number 58 Gt CO2eq does not tell the reader very much. And as you explain below, there are some caveats to the use of this number. I simply suggest avoiding using this aggregated number.	Rejected. We will continue referring to CO2eq numbers where required.	Fuglestvedt	Jan	CICERO	Norway
26817	14	14	14	14	change "tracked at" to "were"	Accepted	Verchot	Louis	International Center for Tropical Agriculture	Colombia
27515	14	14	14	14	Where does the 38 Gt CO2 number come from? It doesn't appear in the following text.	Rejected. It comes from Figure 2.2.	Collins	William	University of Reading	United Kingdom (of Great Britain and Northern Ireland)
41083	14	9	14	18	I suggest you explore other ways of presenting what you want to say here. You may focus on the growth of each individual gas instead.	Noted, but we will also refer to CO2eq figures where required.	Fuglestvedt	Jan	CICERO	Norway
27517	14	14	14	18	It would be better to give these numbers as Gt of each gas seperately rather than converting to CO2-eq. The conversion depends strongly on metric (by about a factor of 10 according to box 2.2 table 1).	Rejected. We continue using GWP-100 where necessary. We discuss emission metrics in a dedicated box and provide a new figure on warming impacts to balance this use of GWP-100.	Collins	William	University of Reading	United Kingdom (of Great Britain and Northern Ireland)
36419	14	20	14	20	Above you use AR5 and AR6 respectively but here 'Fitfth and sixth assessemnt'. Maybe you can stay with the former	Accepted	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
14571	14	24	14	25	Please also indicate whether you take the GWP values that include carbon cycle feedback or not. Maybe consider to update this with the latest updated GWP values in AR6 WG1 Chapter 7.	Accepted.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
41087	14	25	14	27	And this change of 33% is a result of many changes related to CH4, but also due to changes in the AGWP of the referecne gas. See discussion in ch8 WGI AR5 of what drives GWP changes over time.	Noted, but too specific for our discussions here. We make a reference to WGI chapter 8).	Fuglestvedt	Jan	CICERO	Norway
41085	14	19	14	30	You explain well why the use of CO2eq emissions is problematic. Since this aggregate is used a lot in the literature, reports and assessment, I think you should keep this explanation, while also avoiding its use as much as posisble	Noted	Fuglestvedt	Jan	CICERO	Norway
21019	14	32	14	32	what is the attached uncertainty to the 51% growth of GHG?	We do not attach uncertainties to estimates of emission growth.	MOSTEFAOUI	MOUNIA	LMD - ENS- Sorbonne	France
27519	14	32	14	33	Is the emission grown for CH4 and N2O from FFI as well, or do these include FOLU too?	These are changes in total CO2 FFI, N2O and CH4 emissions as reported here.	Collins	William	University of Reading	United Kingdom (of Great Britain and Northern Ireland)
26819	14	34	14	35	This sentence gives the impresion that emission of N2O and F gases are about the same, when in fact emission of F gases are still less than 60% of N2O when expressed in CO2 equivalends, Average N2O emissions for the decade 2007-2016 was 2.8 GtCO2e (see SRCCL)	Accepted. We have added a table with average annual emissions across the decade and deleted the direct comparison.	Verchot	Louis	International Center for Tropical Agriculture	Colombia
26087	14	35	14	41	The outline of WGI AR6 includes historical trends and variability of CO2 and others. I suppose that the WGI will provide more insights into CO2 emissions from FOLU, which should be shared in the WGIII report.	Noted. There is a devoted chapter on this in WGIII. Also, we have extended our treatment here.	Tsutsui	Junichi	Central Research Institute of Electric Power Industry	Japan
36421	14	1	14	43	Many subscripted 2 in CO2 have an 'eq' attached which I guess stands for 'equivalents'? However this has never been introduced anywhere earlier	Rejected. It is introduced right at the beginning of the chapter, but we made it even clearer.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
47505	14	41	14	43	An indication of the trends of total CO2 (including bioenergy) from these processes could be informative and help transparency, especially in light of the reported uncertainty in LUC emissions. Bioenergy CO2 emissions are reported as memo items in the inventories.	Rejected. Chapter is already battling with information overload. Should be treated in energy systems or AFOLU chapters	Rakonczay	Zoltán	European Commission, Directorate General for Research	Belgium
26821	14	42	14	43	Just say: did not increase further.	Accepted. Changed.	Verchot	Louis	International Center for Tropical Agriculture	Colombia
1271	14	31		32	provide evidence to make clear	Rejected. The evidence is clearly laid out in Figure 2.2.	Anoruo	Chukwuma	University of Nigeria, Nsukka	Nigeria
1273	14	41		43	provide evidence to make clear	Rejected. The evidence is clearly laid out in Figure 2.2.	Anoruo	Chukwuma	University of Nigeria, Nsukka	Nigeria
47641	14	1			Figure 2 - nice figure - AR5 , AR6 AR2 lables difficult to spot - can you make them more prominent	Thanks. We changed the text font for these labels to bold.	Slade	raphael	Imperial College	United Kingdom (of Great Britain and Northern Ireland)
36423	15	1	15	1	In the caption is says GHG emissions 1990 -2017 while data on time axis in Fig a. says 2018 where I guess should be 2017. the juxaposed for AR6 on right side shows other data for 2018 then; Not sure what 'original units' on y-axis in fig b. means whithout reading the caption. Maybe remove in Figure?	Accepted. Clarified.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
12129	15	1	15	2	I like figure 2.2. - please keep	Thanks.	Kvalevåg	Maria Malene	Norwegian Environment Agency	Norway

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38353	15	2	15	2	1990-2017 should be changed to 1990-2018	Thanks, done as suggested.	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
38355	15	6	15	6	I believe the phrase "from the IPCC Fifth Assessment Report" can be removed since that report only showed values to 2010 and this goes to 2018.	Rejected. We are talking about GWP values - not emission levels.	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
38767	15	1	15	10	It seems odd to place the waterfall diagram for 2018 from AR2 GWP after AR5 and AR6. By placing it in order of ARs, one can see how the estimates have obviously gotten better through time and closer to 2018. Unless there is a specific reason AR2 GWP for 2018 is placed last, but this isn't not stated in the caption.	Noted. The order of the GWP waterfall will change in the SOD as we receive fully updated GWPs for AR6. We then plan to show them in declining historical order (AR6, AR5, AR2) for comparison.	Reyes	Julian	Personal Capacity	United States of America
41089	15	1	15	10	I understand that there are reasons for using the CO2 eqivalents aggregate in the upper part of fig 2.2, and it is good that you show the impctac of different sets of GWPs. I also support the use of panels for the four gases below. This is an improvement from AR5.	Thanks.	Fuglestvedt	Jan	CICERO	Norway
36425	15	12	15	12	Here you say 'CO 2 emissions reached 43 (±4.1) Gt in 2018 compared to 39 (±3.7) Gt in 2010'. However these are different numbers than shown in Fig 2.2a where the numbers are higher. So to which part are you refering here?	Rejected. The numbers are consistent with Figure 2.2: it is CO2-FFI+CO2-FOLU.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
21021	15	12	15	14	The uncertainties associated to CO2 emissions during one year are of 10% , about ten times bigger than the annual average growth? If so, is this number relevant?	Rejected. Uncertainty ranges in asbolute numbers associated with emission levels cannot be applied to emission growth rates.	MOSTEFAOUI	MOUNIA	LMD - ENS- Sorbonne	France
38357	15	15	15	15	I think that the phrase "fuelling hopes" is a bit unscientific and should either be removed or changed to something like "seeming to indicate".	Accepted and changed	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
36427	15	12	15	21	As the main focus in this paragraph is on the period 2010-2018 I suggest I) maybe somehow highlight this period in Fig 2.2.a and ii) wondering as there is no reference to earlier years whether the figure should not simply show values for the 2010-2018 period as then details that are discussed here, would become much better visible	Rejected. We have taken the decision as an AR6 author team to focus on the period 1990-2018 as many climate policy commitments still refer to that year. Our main analytical interest is the change from the AR5 end year (which was 2010). Both periods are important.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
24827	15	18	15	21	Delete "Overall, the increase … Friedlingstein et al. 2019)."	Rejected. No rationale why that sentence should be deleted.	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
38359	15	18	15	21	Here you explain that the growth in CO2 emissions 2010-2018 is mostly from gas (you should say natural gas) and oil, but when looking at Figure 2.3a, it is difficult to see this. Since you're focusing on 2010-2018, could you provide the shares for those two years instead of for 2000 and 2018?	Rejected. We provide references to the paper with the underlying data (Global Carbon Budget). Interested readers can go there. For consistency of the narrative we keep the language as is.	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
10785	15		15		Figure 2.2 should also appear in executive summary of Chapter 2. Please note that this figure appeared in even the SPM of AR5 and also Synthesis report because of its value.	Noted	Yamaguchi	Mitsutsune	Research Institute of Innovative Technology for the Earth	Japan
10319	15	1			Nothing technically wrong with the figure, but the different bars for the different GWPs make the figure look like it's providing a projection into the future. This will be a key figure for communicating basic facts about emission trends so it's worthwhile making this figure work from a communication perspective. Also consider showing shaded uncertainty ranges for panels b-e, and putting all panels relative to a zero baseline so one can see relative trends.	Noted	Reisinger	Andy	NZAGRC	New Zealand
6905	15	2			Figure 2.2: 1990-2017 should probably be changed to 1990-2018	Thanks. Done as suggested.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
18417	15				It is suggested to divide the figure 2.2 into two figures : CO2 and non-CO2. There are lots of uncertainties in the estimation of non-CO2. it should not be presented in the same figure of CO2.	Rejected. We believe there is policy relevance and demand for showing all gases in this figure (see positive reviews, e.g. in comments 10785, 41089, 12129, 47641). We share the concern that aggregating gases using global warming potentisl (GWPs) is complicated, and have therefore provided subplots showing individual gas trends, as well as a side-panel to the main figure that compares different GWP values. We show uncertainties in gas specific insets.	Shiyan	Chang	Tsinghua University	China

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47507	16	1	16	2	"Looking at the long term, anthropogenic CO2 emissions were mainly from land-use, land use change and forestry at the outset of the industrial revolution:" This sentence is confusing and potentially misleading. The bulk of the mentioned emissions came from energy/industry (mining, metallurgy, etc) where biomass (mostly wood) was used for energy. The fact that today's GHG inventories would classify such CO2 emissions under the inventory sector of land (earlier LULUCF, today AFOLU) does not change the fact that the emissions were driven by and actually took place in the economic sectors of energy, industry and mining, where the biomass was combusted or otherwise used. It is also confusing as it refers to "land-use, land use change and forestry", which is not an economic sector, but the name of a GHG inventory sector, which is inconsistently used in the text (mostly replaced by "FOLU").	Rejected. Looking at the figure this statement remains true - even though we acknowledge that biomass was an important energy source. The statement is also backed by the literature (e.g. Friedlingstein et al. (2019). For the report classification is a challenge, but we had to decide on these as an author team across chapters. We cannot permanently change.	Rakonczay	Zoltán	European Commission, Directorate General for Research	Belgium
26823	16	1	16	3	FOLU emissions have not remained constant over time, but how you percieve it depends on what scale you use. The literature shows a peak in the mid 1900s when emissions were an order of magnitude greater than they were in the early 1800s. If your starting point is the beninning of the industrial revolution, then emissions today are 3 to 4 times higher than historical emissions. Using the scale of Fig 2.3, these ups and downs are not perceptible against the massive growth of fossil fuel emissions	Noted, but this statement refers to the figure with long-term CO2 emissions trends. It is adequate to say that CO2 emissions from AFOLU have been comparatively stable compared to CO2 emissions from fossil fuel combustion and industrial processes.	Verchot	Louis	International Center for Tropical Agriculture	Colombia
31959	16	12	16	14	This misrepresents SR1.5, which quoted budgets for both GMST and GSAT warming and included 67th, 50th and 33rd percentiles. To select only the lowest number, and quote it with no indication of uncertainty or sensitivity to definitions, is deeply misleading and prescriptive to the point of seeming policy-driven. Both definitions and the range should be quoted to avoid the complete mess we got into with AR5, ending up with a budget that was clearly wrong (it is exhausted already, and no one is claiming we are already at 1.5C) with no sensible way of revising it because it had been presented in this way as a single number, so even a modest revision was seized upon as overturning the entire apple-cart.	Accepted. We provide carbon budget estimates in line with WG1 AR6 at 33rd, 50th and 67th percentile. We further report scenario uncertainty of +/i 250. However, in the figure we show all budgets (panelb), but provide budget exhaustion and net-zero estimates only for 67th as figures gets too busy otherwise.	Allen	Myles	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
32387	16	11	16	16	According to Table 2.2 in the IPCC Special Report on 1.5C, non-CO2 emissions and Earth system feedbacks like permafrost thaw can further decrease the carbon budget, making achieving the goal of limiting warming to 1.5ºC that much more difficult. See also Pistone K., et al. (2019) Radiative Heating of an Ice-Free Arctic Ocean, GEOPHYSICAL RESEARCH LETTERS 46(13):7474–7480 (calculating the loss of all sea ice for the entirety of the sunlit months could add the equivalent of 1 trillion tons of CO2). Similarly, early saturation of land sinks, and the transition to sources, also can reduce the carbon budget and the time to achieve net zero emissions. See e.g., Wannes Hubau, et al. (2020) Asynchronous carbon sink saturation in African and Amazonian tropical forests, Nature.	Rejected. More detailed discussions on the carbon budget are beyond the scope of the chapter. This is provided in the WG1 AR6 assessment. We will make sure that our assessment here is consistent. Any details on budgets will be provided in WG1.	Zaelke	Durwood	Institute for Governance & Sustainable Development	United States of America
32765	16	11	16	16	Per the IPCC Special Report on 1.5C, non-CO2 emissions and key feedbacks like thawing permafrost can further decrease the carbon budget, making achieving the goal of 1.5C that much more difficult.	Rejected. More detailed discussions on the carbon budget are beyond the scope of the chapter. This is provided in the WG1 AR6 assessment. We will make sure that our assessment here is consistent. Any details on budgets will be provided in WG1.	Campbell	Kristin	Institute for Governance & Sustainable Development	United States of America
26089	16	15	16	16	The WGI assessment of the remaining carbon budget will be updated, and I believe there are many uncertainties to be taken into account not only for climate response but also for non-CO2 scenarios. Saying 'these budgets will be exhausted in 9 and 27 years' is too simplistic and should not be put into the executive summary as it is.	Noted. We acknowledge uncertainties now, but still provide budget exhaustion calculations as example in the same way.	Tsutsui	Junichi	Central Research Institute of Electric Power Industry	Japan
44467	16	17	16	19	Unclear what "substancial atmospheric CO2 removal" could mean here. Seems only to make sense if you talk about net negative emissions, which on the other hand doesn't make sense if you talk about the decade until 2030. Gross CDR would be covered by the NDCs	Noted. Text has been revised.	Geden	Oliver	German Institute for International and Security Affairs	Germany
14579	16	25	16	26	Cross-reference IPCC WG1 AR6 Chapter 5, sections 5.5. and 5.6 and include insights on reversibility from there in this section.	Accepted	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
40067	16	25	16	27	Please discuss the problematic nature of overshoot-and-return scenarios, including shifting the burden to future generations as well as the adaptation needs in two directions (once when the overshoot starts, and again, when tempreature decreases after the overshoot). Relevant literature includes: Geden, O., & Löschel, A. (2017). Define limits for temperature overshoot targets. Nature Geoscience, 10(12), 881-882; Lenzi, D. (2018). The ethics of negative emissions. Global Sustainability, 1(7).	Rejected. This is not the right place to this. Chapter 3 is dealing with such issues.	Michaelowa	Axel	University of Zurich	Switzerland

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43377	16	25	16	27	Overshoot-and-return scenarios are highly problematic and the current text doesn't do justice to the issue: There are important intergenerational issues with putting the (potentially unfeasible) burden of Gt scale CO2-removals (on top of near-complete decarbonization) to the future generation along with the added climate impact of temporarily exceeding temperature targets and returning back (which in and of itself is expcted to cause adaptation needs). Geden, O., & Löschel, A. (2017). Define limits for temperature overshoot targets. Nature Geoscience, 10(12), 881-882. Lenzi, D. (2018). The ethics of negative emissions. Global Sustainability, 1(7). Nusbaumer, J., & Matsumoto, K. (2008). Climate and carbon cycle changes under the overshoot scenario. Global and Planetary change, 62(1-2), 164-172.	Rejected. This is not the right place to this. Chapter 3 is dealing with such issues.	Honegger	Matthias	Perspectives Climate Research gGmbH	Germany
10321	16	11	16	29	This section will need important harmonisation with WGI assessment of carbon budgets. Focus on what the relevant WGIII contribution is, and re-state what the WGI conclusion is. Currently it isn't clear what's what, which raises the prospect of inconsistency. Also it would be important to clarify the role of non-CO2 emissions (which are assessed in the WGIII report) in carbon budgets - which provides an important handshake with chapter 3 (and 7, and 12).	Accepted	Reisinger	Andy	NZAGRC	New Zealand
14573	16	11	16	29	Update with AR6 carbon budget estimates from 2020 onward, available in AR6 WG1 SPM SOD, or alternatively see Section 5.5 in AR6 WG1 Chpater 5 for a more detailed table.	Accepted	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
14575	16	11	16	29	The discussion of emissions reduction rates should be reconsidered on it scientific merits and adequacy. First, the mathematical functional form for CO2 emissions decline chosen (a compound annual decline rate) is not useful for emissions that need to go to zero, as this functional is unable to model such a decline. Stating that this only applies to gross emissions is not an adequate reason, because current emissions are already net emissions, in which global emissions and removals are combined to provide the 43 GtCO2 estimate of current global emissions. A simple linear decline rate relative to a fixed historical year provides here an easy and adequate alternative - consitent with IPCC SR1.5.	Accepted	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
14577	16	11	16	29	The discussion of gross and net emissions is confusing and seems to forget that estimates of current emissions are already net global emissions in which gross CO2 emissions are reduced by the removals in individual geopgraphies. Note that global LULUCF emissions are indeed net estimates and not gross as suggested in this paragraph. This should thus be made internally consistent with the discussion in the chapter. Either the estimates of the historical emissions also need to indicate gross CO2 emissions (which I wouldn't recommend given how they are used in UNFCCC) or the discussion here needs to be corrected to adequately reflect the nature of the emissions described.	Accepted. We clarified the text.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
44469	16	22	16	29	Gross vs. Net releases: that's correct but probably confusing if not supported by a figure. And if there's no room for a figure I'd rather delete this	Accepted. Text changed.	Geden	Oliver	German Institute for International and Security Affairs	Germany
30449	17	1	17	1	Figure 2.3 is a really helpful figure/visual, thank you,	Noted. Thanks!	Cook	Lindsey	Quaker United Nations Office / Friends World Committee for Consultation (IPCC Observer)	Germany
41091	17	1	17	12	Figure 2.3, panel b: I suggest you include uncertainty ranges here.	Accepted.	Fuglestvedt	Jan	CICERO	Norway
41093	17	1	17	12	Figure 2.3, panel c: please check consitency with WGI and WGIII Ch3	Noted	Fuglestvedt	Jan	CICERO	Norway
47513	17	1	17	12	Figure 2.3: The terminology referring to land use is confusing. The amounts labelled in the chart as "net land-use" (sic!) essentially represent land-use change, that is the "LUC" part of LULUCF. In contrast, the caption refers to the same as "forestry and land use", strongly suggesting the non-LUC part of LULUCF. It could also be interpreted as the CO2 part of AFOLU, which is elsewhere referred to as "FOLU", but that is equivalent to LULUCF. This terminological confusion is traceable throughout the whole draft.	Accepted. We have now inserted a clear definition of what we now call AFOLU CO2 emissions and consistently refer to it.	Rakonczay	Zoltán	European Commission, Directorate General for Research	Belgium

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
14581	17	19	17	21	Update with AR6 WG1 SPM SOD assessed temperature ranges for these scenarios (see SPM for a subset and chapter referenced therein).	Note. This section is still a bit in flux. We were focussing on other things at this moment. The figure is not there anymore. If we keep temperature ranges in the text, we will update the temperature ranges in line with WG1 for the final draft.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
10323	17	14	18	6	This section should tackle explicitly the discussion around RCP8.5 and assess the extent to which its use remains relevant, and why (picking up on recent Hausfather and Peters paper, amongst many others). It doesn't seem helpful to ignore the lively discussion around RCP8.5 even if the liveliness often occurs in the margins of academic publications.	Accepted, but we only briefly refer to it. We believe that there is a wider baseline discussion beyond what a baseline is that points towards some bias in the models towards fossil fuel consumption.	Reisinger	Andy	NZAGRC	New Zealand
42673	17	14	18	27	The rationale of Fig. 2.4 need to be clearly explained. The text need to be re-written.	Accepted. We have adjusted the figure and revised the text.	CHHABRA	ABHA	Space Applications Centre, Indian Space Research Organisation	India
2309	18	7	18	7	Hard to distinguish colors in lower panels. Thicker and continuous lines would help	Lower panels have been removed.	Martinerie	Patricia	CNRS	France
14583	18	7	18	7	Include the core set of five scenarios assessed in IPCC AR6 WG1 for consistency: SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0, SSP5-8.5	Accepted. Panels show SSPs now. Top left panel has been removed though.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
14585	18	7	18	7	Update lower panels with AR6 database, or at least with the full SSP database and SR1.5 database which also include very low energy demand scenarios (illustative pathway P1 in IPCC SR1.5).	Panels have been removed.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
30451	18	8	18	8	The RCP/historical and current emissions fgiure shows us going off RCP8.5 and toward RCP6. This seems a slight improvement from a few years ago, when this chart had emissions still following an RCP8.5. Am I correct with this interpretation? Does that give something to see as a small achievement, still confusing as though you write the rate of emissions is slowly, emissions overall are increasing. Is that what we are seeing on this chart? These might be policymaker questions too.	Noted. We changed the figure. But the figure highlights that emissions are still tracking at the middle to higher range of baselines (in the short term). However, we also highlight in the text that particularly the recent SSP baseline could be overly pessimistic in the long-term. Particularly, it is hard to see a RCP8.5 when you analyse the underlying trend and compare it with history.	Cook	Lindsey	Quaker United Nations Office / Friends World Committee for Consultation (IPCC Observer)	Germany
36429	18	8	18	8	Axis labels and numbers of figure 2.4 are too small to read properly. Moreover in caption are far too much jargon and unintroduced abbreviations in to fully understand. Parts of the interpretation given here can be moved to the main text as it is of no relevance here	Noted	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
2311	18	8	18	27	The Figure and related text lacks background on the nature of the different sets of scenarios to be understandable as a standalone. Commenting the sets of scenarios rather than individual scenarios in the caption would help.	While this is true, we do not have the space for that. We refer to a series of paper, which discuss these.	Martinerie	Patricia	CNRS	France
26165	18	8	18	27	Fig 2.4 and explanation take to much time to be digested unless you spend a great deal of time. Consider shorter and sharper comments for figure 2.4	Accepted. We changed the figure and shortened the cpation	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
26305	18	30	18	30	In my view, this box generally provides a balanced overview of the development of GHG emission metric research, although I provide specific comments for several individual parts of this box.	Noted; thank you.	Katsumasa	Tanaka	Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CEA, FRANCE; National Institute for Environmental Studies (NIES), JAPAN	France
28459	18	32	18	32	I judge Box 2.1 to be a good start of what could become an excellent section on emission metrics, although I have strong reservations about one present section. I think the main issue is that it is quite hard to "audit" the route by which the GWP100 is effectively endorsed on Page 22, line 10, as it seems that different lines of reasoning have been implicitly given different weight.	Accepted: the box has been shrunk to 2 IPCC pages and remaining detail shifted into Appendix B. The revised box has sought to clarify the relationship between policy goals (of which mitigation costs, both idealised and real-world) and GHG metrics.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
28461	18	32	18	32	Given my experience of discussing metrics with the policymaking community, I was surprised that there was no discussion of the value of maintaining the use of GWP100 for continuity-of-policy purposes. I have often heard the statement that it would be disruptive (in a negative sense) to change the metric. Given the quasi-random process that led to the GWP100 being adopted in the first place, this seems one of the more compelling arguments for its continued use. This feels as though it is an implicit piece of reasoning throughout the text, but it is never made explicit.	Noted; we have added a brief section on implications of changing metrics for policy, recognising the limited literature that deals explicitly with the issues related to changing GHG emission metrics.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
42675	18		18		Fig 2.4 panels are poorly illustrated. The whole Figure need to be redrawn with improved legend text.	Accepted. We changed the figure and shortened the cpation	CHHABRA	ABHA	Space Applications Centre, Indian Space Research Organisation	India
44477	18	28	19	19	Already in the intro, you should highlight the importance of net zero	Accepted; the intro has been revised to give a clearer outline of policy contexts in which GHG metrics are used, and net-zero targets are one of those.	Geden	Oliver	German Institute for International and Security Affairs	Germany
42677	18	30	19	19	It is suggested to include a brief on Global Warming Potential (GWP) and Global Temperature change Potential (GTP), two main metrices as part of Box 2.2.	Taken into account; we consider that the FOD already provided this, but we have revised and extended this discussion (shifted into Appendix B) and hope that this provides this brief even more clearly.	CHHABRA	ABHA	Space Applications Centre, Indian Space Research Organisation	India
6907	18	29	24	21	The box should include a discussion that GTP is connected to more uncertainties and assumptions than GWP	Accepted; the discussion of GTP has been extended (in the Appendix).	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
6911	18	29	24	21	The definition of GWP* in the box is difficult to understand, and it should be better explained what "blanace of sources" means when revising the discussion of GWP*	Accepted; we have attempted to clarify the discussion of GWP*.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
14603	18	29	24	21	I generally find the labelling "pulse" versus "step-change" a bit confusing. A pulse also involves a step-change. Maybe some alternative unambiguous labels can be thought of, unless this categorisation is well established in the literature (which I don't think it is).	Rejected; the term "step change" is also used in WGI so we also use this term for consistency (we don't see why a pulse is a step?). The terminology of "emissions pulse" is used widely in the emissions metric literature. However, we have attempted to further clarify those concepts at their first introduction.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
44471	18	29	24	21	It's a bit too long for a box, isn't it? (you probably know that already)	Accepted; the box has been shrunk to 2 IPCC pages, with additional material shifted into Appendix B since many reviewers and authors considered that it was important not to lose the detail entirely.	Geden	Oliver	German Institute for International and Security Affairs	Germany
2333	18	30	24	21	I found the discussion of metrics too long and technical. A shorter text and synthetic table with advantages/disavantages of the different metrics could help. The quick mention p22 l41-45 that climate models remain the reference could be developed and mention the concept of tipping points	Accepted (mostly). The box has been shrunk to 2 IPCC pages, with additional detail (which other reviewers and authors considered important) shifted to Appendix B. The revised text clarifies the relationship of metrics to climate policy goals. We do not consider a reference to tipping points to be relevant here, apart from the generic climate policy goals to reduce the rate and/or magnitude of climate change.	Martinerie	Patricia	CNRS	France
47647	18	30	24	21	Box 2.2 - Can we take out Box - publish it and reference it - or move to annex B. a 6 page discussion on GWP metrics is out of balance link between choice of metric and real world mitgation cost could be elaborated	Accepted: the box has been shrunk to 2 IPCC pages and remaining detail shifted into Appendix B. The revised box has sought to clarify the relationship between policy goals (of which mitigation costs, both idealised and real-world) and GHG metrics.	Slade	raphael	Imperial College	United Kingdom (of Great Britain and Northern Ireland)
24239	18	7			Figure 2.4 is not high-resolution enough. There is room to be improved.	Noted. The figure was replaced.	Zhifu	Mi	University College London	United Kingdom (of Great Britain and Northern Ireland)
47643	18	8			Figure 2.4 - need to introduce SSPs , RCPs and scearios before discussing.	Noted. The figure was replaced.	Slade	raphael	Imperial College	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
27521	18	29			Box on emission metrics: This box focusses particularly on the use of emission metrics in IAMs to construct cost-optimal mitigation pathways, showing that using GWP100 leads to errors of less than 5% in the cost optimisation. However chapter 2 uses emission metrics far more widely than this, for instance reporting measured emission trends in CO2-eq - which has nothing to do with cost-optimisation. It has been robustly shown (e.g. Fuglestvedt et al. 2017 Phil. Trans. R. Soc. A, Collins et al. 2020 ERL) and many others that the GWP100 cannot be used to assess the contribution of short-lived species towards a carbon target. Therefore the very first ES of this report (emissions of 58 GtCO2-eq) is misleading in overstating the rate at which we are using up a carbon budget. Such considerations need to feature prominently in the discussion. While the cost implications for aggregated mitigation measures may not be too far out, when the GWP100 metric is used to evaluate the benefits of specific mitigation measures in later chapters (e.g. 5.3.3.1, 7.6), overstating the impact of methane will therefore also skew the impact of individual measures.	Accepted in part; we set out more clearly the different policy contexts for GHG emission metrics. We don't feel that the box focuses particularly on cost-optimal mitigation - this is covered in one section, but other sections cover other aspects. We also disagree that GWP100 is relevant only for cost-minimisation; it is relevant in many other policy contexts where it is important to understand the contribution from future GHG emissions to future climate change (and hence the amount of climate change that could be avoided by avoiding these emissions). The text has been revised to make the different policy contexts clearer. We disagree that describing current emissions as 58 Gt CO2-eq is misleading, since this figure is not being presented as using up a carbon budget - it presents the total contribution from emissions in each year to integrated radiative forcing over the next century, which is the key driver of climate change during the 21st century. The main Chapter 2 now includes a figure that shows the actual warming outcome from methane emissions to date rather than only emissions weighted by GWP100.	Collins	William	University of Reading	United Kingdom (of Great Britain and Northern Ireland)
14367	18				Figure 2.4 is very poor, the figure itself is far too small to make sense and notes below seem excessive!	Noted. The figure was replaced.	Bradshaw	Michael	University of Warwick	United Kingdom (of Great Britain and Northern Ireland)
14587	19	1	19	2	Consider making this more specific: Greenhouse gases and aerosols differ widely in their atmospheric lifetime and the sign and magnitude of their effect on global-mean temperature rise.	Accepted; text revised accordingly	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
14589	19	3	19	4	The real problem is rather "aggregating" than "reporting". The easiest way, which doesn't pose any problem or "challenge" due to the multitude of climate forcers is to report species individually. So maybe change this to "aggregation" or "aggregated reporting", or some other variant.	Taken into account; text revised consistent with this and other comments.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
15933	19	3	19	4	Is it only reporting area? How about MRV areas (Measurement-Reporting-Verification)?	Accepted in part; it is not the full spectrum of MRV but the aggregation of emissions. Text revised consistent with this and other comments.	Takarina	Noverita	Universitas Indonesia	Indonesia
26269	19	3	19	8	My preception is that mitigation is part of pathways. I think the two bullets can be put together. More importantly, this bullet can highlight the fact that metrics play a key role in the Internationally Transferred Mitigation Outcomes, or emission trading in general.	Taken into account; the presentation of policy contexts in which GHG emission metrics play a role has been extended consistent with this and other comments. We have kept the three initial bullets though, since we think there is a distinction between choices about and trade-offs between abatement of individual emissions (e.g. on an annual basis in emissions trading schemes) and the setting of longer-term targets and pathways.	Katsumasa	Tanaka	Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CEA, FRANCE; National Institute for Environmental Studies (NIES), JAPAN	France
28463	19	9	19	9	Maybe use a different term than GHG, as potentially metrics can be for aerosols, precursors etc	Rejected; in this box we focus on GHG emission metrics only (but the revised text makes clear that in principle, metrics also exist to evaluate the impact of aerosol and precursor emissions - but are not evaluated in this box). We have revised the text to make clear that while in principle metrics can also be applied to aerosols, this box focuses on GHG metrics as this is where most of the policy interest lies, and countries are currently reporting and some are setting targets for aggregated GHGs, but not for aggregated GHG and aerosol emissions.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
41095	19	9	19	9	I suggest changing "GHG metrics" to "emission metrics" (but please be consistent across chapter)	Accepted; we now consistently use "GHG emission metrics".	Fuglestvedt	Jan	CICERO	Norway
41097	19	9	19	9	Should it be "reporting" rather than "accounting" ?	Accepted.	Fuglestvedt	Jan	CICERO	Norway
28465	19	10	19	10	It is not clear whether "alternative" covers the same metrics with different time horizons. What is written is equally true for GWP20 and GWP100 as it is for GWP100 and GTP100.	Accepted; we had intended this to cover broadly both different metrics and different time horizons; text has been clarified.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
14591	19	9	19	13	I would disagree with the statement that GHG metrics "are intended to inform decision makers about the aggregate effect of, and trade-offs between, actions on different emission sources and sinks". The actual intention of GHG metrics is at a much more basic level which comes before the intention to inform decsion makers about the aggregate effect. This could be dealt with by, for example, writing that: "GHG metrics are intended as simplifying and practical tools to express the different climatic effects of various GHGs in a way such that they can somehow be compared and aggregated, often with the ultimate aim to inform decision makers about how actions on different GHG emission sources and sinks compare and add up. Alternative metrics reflect different aspects of the climatic effect of GHGs and can thus result in a different importance assigned to both the scale and timing of emissions abatement. Therefore, all metrics rely on implicit value judgements about how past, present and future emissions are accounted for and what aspects of the climate system and what time horizons or reference periods are considered."	Taken into account; we are unsure whether the revised text proposed by the reviewer is fundamentally different to the existing text, but we have taken the proposed formulation into account in our revision.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
36431	19	9	19	13	As it is now I do not fully understand what are the intention of this box. Maybe move paragraph lines 9-13 up as starting sentences	Noted: we have substantially shrunk and hopefully focused this box; technical details (which we consider important to justify the conclusions) have been shifted into Appendix B.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
44473	19	14	19	15	Not "the Paris Agreement", but "the parties to the Paris Agreement", since this refers to a COP24 decision (Decision 13/CMA.1), and this decision leaves open wheter to use GWP100 from AR5 or from subsequent IPCC reports, and I'm mot sure if the meaning of the decision is really covered by the term "default"	Accepted; text has been revised accordingly, with detail covered in the Appendix.	Geden	Oliver	German Institute for International and Security Affairs	Germany
28467	19	15	19	15	"Paris … decided to use GWP100". I am not entirely sure that this is fully correct. I have always understood the referred document (UNFCCC 2018) to refer specifically to National Inventory Reporting, and the lack of decisions within SBSTA means that it is not clear that this same decision applies to NDCs etc.	Accepted; text has been revised accordingly, with detail covered in the Appendix.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
28469	19	16	19	16	Maybe use a different term than GHG, as potentially metrics can be for aerosols, precursors etc	Rejected; this text is purely factually descriptive of what we cover in this box. Revised text above this sentence has clarified that in principle, metrics can also be used to evaluate the impact of aerosols, precursors etc.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
28471	19	18	19	18	"dominant" - perhaps replace with "important", given that methane isnt clearly more dominant than aerosols	Taken into account; we have kept the word "dominant" but clarified that this applies to gases only.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
14593	19	14	19	19	This paragraph should probably be a bit more precise as to in which context precisely GWP-100 is required and in which contexts countries can decide on also including other metrics (e.g. in the formulation of their NDC). A clear trace through the various decisions will be necessary here.	Accepted; text has been revised accordingly, with detail covered in the Appendix.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
26271	19	14	19	19	As perhaps implied here, GWP100 has been agreed just for reporting, but it has not been officially agreed for the Internationally Transferred Mitigation Outcomes. This paragraph needs updating, depending on the outcome of SBSTA52, COP26, etc. The paragraph could also say that countries can additionally report their emissions using metrics other than GWP100. This is explicit in the text of UNFCCC (2018).	Accepted; text has been revised accordingly, with detail covered in the Appendix.	Katsumasa	Tanaka	Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CEA, FRANCE; National Institute for Environmental Studies (NIES), JAPAN	France

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
44475	19	16	19	19	Since the box is quite long it would be good to indicate the result of the following considerations already here, before you go through all the details. And if I read this correctly (or is it maybe just my assessment?) the underlying argument is that a political (GWP100) decision has already been made, and combined with the PA Art 4.1 goal of net zero GHG emissions this should be the starting point for any consideration of metrics and if there is ambiguity or ambivalence around the use of metrics then the political decisions should take center stage but analysed in view of different options. The basic argument could be that there are already political decisions/frameworks on mitigation (net zero globally, with GWP100 from AR5 or later), and increasingly national net-zero (GHG) targets as well - but that there are also geophysical considerations worthwhile to be made. Since WG3 is about mitigation, the political relevance of the metrics issue should be prioritized over the scientifically relevant factors	Taken into account in revisions. We did not intend to present the conclusion on GWP100 merely because a political decision has already been made, and the revised text hopefully avoids this misinterpretation. We do consider it important for the IPCC to assess the scientific case (including economic outcomes and match between metric and climate policy objectives, which are all part of WGIII), while recognising political decisions already made.	Geden	Oliver	German Institute for International and Security Affairs	Germany
34573	19	20	19	20	line 20, Summary of key developments since the AR5	Rejected; this section provides a summary of the AR5, and has been revised further to focus only on that rather than an update of developments since the AR5 (this is now a separate section in the Appendix).	Meng	Jing	University College London	United Kingdom (of Great Britain and Northern Ireland)
28473	19	22	19	22	It is left hanging as to whether AR6 is reaffirming this "robust evidence and high agreement" view - I would hope it would.	Noted; as this section is only giving a recap, not the AR6 assessment, it is difficult to pre-empt in this section the AR6 conclusion. However, the intent of this comment has informed the way the revised box (shrunk to 2 pages) presents this issue.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
36433	19	26	19	26	Here the abbrevation SLCF are introduced but except for once more, where the full name is used, in a sentence later it is not used again in the following text. Is it really useful to introduce abbrevation SLCFs? What is the advantage?	Noted; SLCFs are used elsewhere but we want the box to be readable on its own. Editorial decisions will be made after the final draft has been prepared.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
32145	19	26	19	28	The sentence 'for example, a metric that gives consistently less weight to short-lived forcers such as CH4 would require earlier and more stringent CO2 abatement to achieve the same climate outcome for 2100.' is a bit confusing. The sentence implies that you could somehow come to the same climate outcome in 2100 using different metrics for CH4. You wouldn't, as 'net zero' GHGs defined using different metrics for CH4 results in different climate outcomes (eg Fulgestvedt et al 2018 in Phil. Trans.) I assume there would be less of an issue with choice of metric if they actually led to the same climate outcome no matter which metric you used to inform your mitigatio path.	Noted; the sentence is a direct quote from the AR5 SYR, but we have modified it to make it clearer. A different balance between abatement of non-CO2 gases and CO2 does not necessarily result in a different climate outcome (the finding is not tied to 'net-zero'). It is a robust finding across many studies that placing less weight on CH4 abatement requires more CO2 abatement to achieve the same peak and enf-of-century temperature limit.	Cain	Michelle	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
28475	19	29	19	29	It is left hanging as to whether AR6 is reaffirming this "medium evidence" view, given subsequent work.	Noted; as this section is only giving a recap, not the AR6 assessment, it is difficult to pre-empt in this section the AR6 conclusion. However, the intent of this comment has informed the way the revised box (shrunk to 2 pages) presents this issue.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
28477	19	31	19	31	I thnk "high" means "high proportion of"	Accepted	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
2895	19	36	19	37	"whereas GTP compares gases based on the temperature change" to read as: "whereas GTP compares gases based on the global mean surface temperature change".	Accepted (but due to efforts to shrink to the box to 2 pages, this full wording could only be adopted in the Appendix).	Pyrozhenko	Yurii	IPCC TFI TSU	Japan
45131	19	38	19	38	In addition to the statement, “the most commonly used time horizon for GWP is 100 years (GWP100),” references that have used GWP20 could be discussed, such as Skytt et al. (2020) “Global warming potential and absolute global temperature change potential from carbon dioxide and methane fluxes as indicators of regional sustainability – A case study of Jämtland, Sweden” from March 2020 <https://doi.org/10.1016/j.ecolind.2019.105831> and others in the literature.	Accepted for the Appendix; due to efforts to reduce the box to 2 IPCC pages, this detail cannot be accommodated in the main box.	Kilkis	Siir	The Scientific and Technological Research Council of Turkey	Turkey

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
26273	19	38	19	39	I know people often say this, but I don't see any reason why dynamic time horizons cannot be used for GWP. It is just uncommon to do that (an exception: Tanaka et al. (2013, 10.1007/s10584-013-0693-8)).	Noted; but we feel this is unnecessary detail for the discussion in this box and associated Appendix. This is because a dynamic GWP lacks a solid theoretical foundation (cf the dynamic GTP, which is pegged to the expected year in which temperature peaks).	Katsumasa	Tanaka	Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CEA, FRANCE; National Institute for Environmental Studies (NIES), JAPAN	France
28479	19	40	19	40	Given the lack of explanation of other things, I felt the footnote was a but unnecessary	Accepted for the box in the main chapter. However, we have kept this in the Appendix as some users will not fully understand what exactly GTP100, or a dynamic GTP, means in practice, including the relevant metric values in the context of a 1.5 degrees or well-below 2 degree policy goal.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
28481	19	41	19	42	"that temperature is expected to peak in a given mitigation scenario" seems a unnecessarily specific. More generally, the dynamic GTP givens the warming in a speciific year.	Taken into account; the wording has been revised (but we have kept reference to the year of peak temperature since this is the key internally consistent use of GTP in mitigation scenarios, or end of century in some studies - the point is that the year is not arbitrary but should be motivated by the climate policy objective).	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
13461	19	20	20	40	For SLCF, please refer to the WG1 chapter 6.	Accepted	Szopa	Sophie	Commissariat à l'Energie Atomique et aux Energies Alternatives	France
13459	19	20	24	20	The title of the section is trends in the global GHG emissions trajectories, thus the disucssion of GTP and GWP seems not relevant there (and is more WG1 scope).	Rejected; GWP and GTP have been used widely in climate policy and mitigations studies; and the box is intended as cross-chapter box, not specific to chapter 2 only (it just has to be placed somewhere in the report, and chapter 2 seemed plausible).	Szopa	Sophie	Commissariat à l'Energie Atomique et aux Energies Alternatives	France
26167	19	20	24	21	Pages on metrics are too long. They could be considered as an appendix	Accepted; box has been shrunk to 2 IPCC pages, with additional technical details and assessment placed in Appendix B.	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
1965	19	14		19	It is useful that IPCC considers different kinds of metrics and to which cases they are appropriate. However, it could also good to state that an ambitious international agreement, like the Paris agreement, needs metrics which all parties are obliged to use so that the emission reporting is commensurate. For internal activities the countries may select also other kinds of metrics reflecting national circumstances and interests.	Accepted; text has been revised accordingly, with detail covered in the Appendix.	Savolainen	Ilkka	Tech.Res.Ctr. of Finland VTT, emeritus research professor	Finland
1967	19	37			Please, add the word “surface” in the front of the word “temperature”.	Accepted (but due to efforts to shrink to the box to 2 pages, this full wording could only be adopted in the Appendix).	Savolainen	Ilkka	Tech.Res.Ctr. of Finland VTT, emeritus research professor	Finland
24475	20	1	20	1	GTP25 should be mentioned in full text instead of abbreviation to every audience understand as it is firstly appeared.	The abbreviation of GTP100 has been included in the main text in the Appendix, which we consider sufficient introduction of the subscript notion.	WIN	SAN	Environmental Conservation Department, Ministry of Natural Resources and Environmental Conservation	Myanmar
41099	20	1	20	1	A reference to Shine et al., 2007 may be given for the dynamic GTP.	Accepted	Fuglestvedt	Jan	CICERO	Norway
14595	20	1	20	3	Here more insight could be provided. Currently the fact that one needs to assume a hypothetical peak year in the future for dynamic GTP seems to make it extremely subjective and almost by definition less accurate in reflecting its real intent than other metrics (that is, we can be pretty confident that we can't predict the time of peak global warming very accurately based on what we know today). Maybe this insight can be included, or otherwise one could highlight that peak warming is expected to happen around the time global CO2 emissions become net zero. Dynamic GTP could thus also integrate that knowledge. Potentially the latter would benefit from a separate analysis first.	Accepted	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
28483	20	4	20	4	"updated" - this comment on updating covers only part of an important issue, and this other part perhaps should be raised too. I think the current text refers to "dynamic" updating as a path is followed. But more generally, metric values are updated as understanding improves (new values of RE and lifetimes, both for the gas in question and the reference gas). GWP(100) for methane has increased from 21 in FAR/SAR to 34 using the cc values in AR5. I havent done the sums, but this is effectively several decades in time horizon space. This in itself poses potential issues for policy makers and there was a wide diversity of values used in the INDCs for example. Many policymakers have adapted quite easily to these new values, and this may indicate that the policy process is far more adapable to changing metrics than is often implied	Noted; we have added a brief section on implications of changing metrics for policy, recognising the limited literature that deals explicitly with the implications of changing metrics.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
32147	20	8	20	9	The sentence ' This adds 2.75 to 9 metric value for fossil compared to biogenic methane (a difference of less than 10% for GWP100), ' needs reqwiting as the 2.75 is not explained and therefore I am unable to assess if it's accurate.	Reference to WGI AR6 added, this is being stated explicitly in the WGI SOD.	Cain	Michelle	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
26275	20	7	20	10	These statements can be directly supported by Boucher et al. (2009, 10.1088/1748-9326/4/4/044007).	Reference added (in the Appendix, due to need to shrink box in main text).	Katsumasa	Tanaka	Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CEA, FRANCE; National Institute for Environmental Studies (NIES), JAPAN	France
2897	20	10	20	10	"carbon inventories" to read as: "National GHG Inventories". Please refer to the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Vol.1, Ch.7).	Accepted	Pyrozhenko	Yurii	IPCC TFI TSU	Japan
41101	20	12	20	13	Regarding precipitation: A reference to Shine et al 2015 acn be given. This paper introduced teh Global Precipitation-change Potential. Earth Syst. Dynam., 6, 525–540, 2015 www.earth-syst-dynam.net/6/525/2015/ doi:10.5194/esd-6-525-2015	Accepted	Fuglestvedt	Jan	CICERO	Norway
26277	20	13	20	14	The literature for precipitation metrics is missing: Shine et al. (2015, 10.5194/esd-6-525-2015)	Accepted	Katsumasa	Tanaka	Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CEA, FRANCE; National Institute for Environmental Studies (NIES), JAPAN	France
28485	20	13	20	14	Slightly self-serving comment. The Irvine et al. paper (on which I am a co-author) used the AGTP and AGWP, so I don't think it belongs in this list, and I suggest deleting. The Stohl et al. paper is not the primary reference to the precipitation metric, and suggest that my 10.5194/esd-6-525-2015 paper is a more appropriate reference. But I completely agree that these diverse metrics have had essentially no applications in actual policy contexts.	Accepted	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
14597	20	16	20	17	Include "of the climate effects of" emissions…	Accepted	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
14599	20	23	20	24	Include "annual emissions targets" in this list.	Rejected; the context here is what policy question a metric can best inform. A target is a policy goal in itself, and a metric should serve the policy goal, not dictate it.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
14601	20	25	20	26	This sentence is entirely unbalanced - because it is only true in a very particular narrow use of GTP and GWP. That is, if the GWP or GTP CO2 equivalent emissions of short-lived greenhouse gases are cumulated and these cumulated emissions are used as a proxy for global warming, there is an ambiguity in the temperature outcome. However, an entirely equivalent case could be constructued from the opposite perspective. GTP and GWP CO2 equivalent emissions of short-lived greenhouse gases in a given year give a much better indication of the actual warming contributed by these emissions whereas if a GWP* metric would be applied to emissions in a given year one would only have information about the change relative to a previous time period, but not the absolute level of warming contributed. GWP* CO2 equivalent emissions in a specific year thus provide a very ambiguous indication of the climatic impact of emissions. This can be resolved by simply being much more precise in how one describes the various issues. For example (edited the full paragraph): "Mixed 'step-change' metrics such as GWP* that have been developed since the AR5 (Allen et al. 2016; Cain et al. 2019; Allen et al. 2018) intend to express the impact on global-mean temperature from a sustained change in emissions of a short-lived GHG as a one-off pulse (either positive or negative) of CO2 emissions. Cumulated CO2-equivalent emissions expressed in this metric have been demonstrated to accurately reflect temperature change from sustained methane emissions (Forster et al.AR6 WG1 FOD), but this approach has not yet been tested for a comprehensive set of SLCFs or a diverse range of mitigation pathways. The use of GWP* also relies on key value judgements such as the reference level used to calculate any step-change in CH4 emissions and hence the warming-equivalent CO2 emission. Table 2.1 shows illustrative metric values for CH4 and N2O under a range of metrics and time zones. Step-change metrics have distinct strengths and weaknesses compared to the earlier established GTP and GWP metrics. These differences lie in how their CO2-equivalent emissions of short-lived climate forcers relate to global mean temperature increase. Annual CO2-equivalent emissions of a short-lived greenhouse gas expressed with GTP and GWP metrics provide an indication of the total warming effect of the emissions of that gas' emissions in that	Accepted with modifications; broader edits have been made to better explain the differences between metrics in estimating the marginal contribution of emissions to climate change (i.e. climate change with and without those emissions), compared to metrics applications that seek to estimate the contribution of a time series of emisisons to climate change relative to a reference temperature level. GWP* can in principle do both, it depends on whether the step-change in SLCF emissions is relative to a recent emissions year, or relative to pre-industrial.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
26279	20	25	20	26	This argument applies to just a subset of pulse metrics whose values are constant over time. Literature shows that pulse metrics can also reproduce forcing and temeperature evolutions as long as it is allowed to change over time (Wigley et al, 1998, 10.1029/98gl01855; Tanaka et al., 2009, 10.1007/s10584-009-9566-6). This may be true for the dynamic GTP up to the point of stabilization. My understanding is that, to get the pathway right, one needs pulse metrics that are time-dependent or mixed 'step-change' metrics that can be fixed over time. This paragraph needs a clarifiation that it discusses "constant" pulse metrics, but not "dynamic" pulse metrics.	Taken into account in revised text. The point we are trying to make is that IF SLCF emissions are treated as 'equivalent' to CO2, then this would imply (as for CO2) that every emission greater than zero results in additional warming. This is clearly not the case for SLCF emissions if emissions are declining. This has nothing to do with fixed or changing metric values, but with whether metrics incorporate the (declining) warming due to past emissions in the evaluation of the emission in question. The text has been revised to hopefully make that clearer.	Katsumasa	Tanaka	Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CEA, FRANCE; National Institute for Environmental Studies (NIES), JAPAN	France
27523	20	27	20	27	Note Collins et al. 2020 Environ. Res. Lett. 15 024018 formally define the combine step-pulse equivalences of these metrics.	Accepted	Collins	William	University of Reading	United Kingdom (of Great Britain and Northern Ireland)
28487	20	28	20	28	I think Collins et al. 2020 10.1088/1748-9326/ab6039 is important here - the GWP* papers essentially chose to approximate the pulse-step equivalence so that conventional GWP values could still be used, but in a different context. Collins et al. is an "ab initio" derivation that doesn't make the set of approximations needed to retain the GWP values. I am guessing this is what the MGTP values in Box 2.2 Table 1 refer to, although this is never stated, nor is it made clear that these are "unapproximated" GWP* values. I suggest, in the light of the CGTP paper, the text de-emphasises the GWP* in favour of a more generic discussion of combined pulse-sustained metrics, as GWP* is just one (approximated) version of such a metric. Note that the published MGTP paper adopted the acronym CGTP (C for combined, rather than M for mixed).	Accepted; the text has been updated to more consistently draw on the WGI SOD, and states more clearly that GWP* is a special case/application of CGTP metrics (as is also stated in WGI).	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
32149	20	28	20	28	Suggest adding a reference to Collins et al 2020 https://iopscience.iop.org/article/10.1088/1748-9326/ab6039	Accepted	Cain	Michelle	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
28653	20	27	20	29	Also reference W. J. Collins et al., Stable climate metrics for emissions of short and long-lived species—combining steps and pulses, ERL, 2019. The results are broadly convergent with GWP*.	Accepted	Frame	Dave	University of Wellington	New Zealand
28491	20	30	20	30	"Better estimation" is a bit of an understatement here. I would say "Unlike the GWP, the GWP* enables an estimation of the global temperature change", although I recognise there is a nuance here (given the near equivalence of the sustained GTP and the GWP	Taken into account. The text introducing mixed step-change/pulse metrics has been revised substantially in light of this and other comments. However, as Lynch et al 2020 show, GWP* is also not perfect in simulating temperature change, the two metrics (GWP and GWP*) differ by degree not in an absolute sense.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
26287	20	31	20	31	This may come from my lack of understanding, but I am not sure how to test GWP* in mitigation scenarios in the sence of WG3. In the sense of WG1, GWP* can be tested by checking if it can reproduce the forcing or temperature evolution (as done by several studies). But when it comes to a test involving economics, which is a focus for WG3, I am not sure yet how to do. This sentense requires elaboration on what the authors mean by testing GWP*.	Taken into account: this was indeed intended in the WGI sense, i.e. how well is GWP* able to represent temperature change from a range of different emission trajectories. We have now included Lynch et al 2020, which evaluated temperature responses from a range of emissions trajectories, not only global emission scenarios with smoothly varying emissions, and modified the relevant text accordingly.	Katsumasa	Tanaka	Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CEA, FRANCE; National Institute for Environmental Studies (NIES), JAPAN	France
28493	20	31	20	31	"not yet been tested" - I am not sure what this means in the context of comprehensive set of SLCPs. Several of the papers in this area go beyond just methane.	Taken into account. The text introducing mixed step-change/pulse metrics has been revised substantially in light of this and other comments. GWP* has not been demonstrated with gases other than CH4, but CGTP has.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
28655	20	31	20	32	I think "but it has not yet been tested for a comprehensive set of SLCFs or diverse range of mitigation pathways. " is incorrect. Cain et al show how GWP* does under the RCPs, I think. In any case, GWP* will give a better fit to temperatures than GWP, because that's what it was designed to do.	Taken into account: we have now included Lynch et al 2020, which evaluated temperature responses from a range of emissions trajectories, not only global emission scenarios with smoothly varying emissions, and modified the relevant text accordingly.	Frame	Dave	University of Wellington	New Zealand
32151	20	32	20	33	I would note here that regular GWP and GTP also require value judgements on what time horizon in the one of relevance. Selection of a metric is entirely based on value judgements about what you are interested in measuring. As GWP100 is the de facto metric, it seems importsant to emphasise that use of GWP100 isn;t without its own problems, as the WGIII readsership may be less familiar with all the WGI literature on this topic. INdeed many in the WGI are uninformed about this.	Taken into account: the dependence of GWP and GTP on the choice of time horizon, and the mismatch that this may create with specific policy objectives, has been stated explicitly in the revised text.	Cain	Michelle	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
28657	20	32	20	34	" The use of GWP* also relies on key value judgements such as the reference level used to calculate any step-change in CH4 emissions and hence the warming-equivalent CO2 emission" GWP* reflects the warming from when you start using it. If that's 1990, it captures the warming since 1990. If that's 1750, then it wouild capture the warming since 1750. It's not so much the reference emission levels that are a "value judgement" but the time at which you start counting the emissions. All metrics have value judgements - the (odd, never actually justified) judgement sitting beneath GWP100 is that 100-year time-integrated radiative forcing is the right way to assess pulses of gases. But because it's a habit, it goes uninterrogated. You shouldn't set a different test for innovative metrics than you do for the Kyoto-era metric. But I think that's the effect (and intent) of some of the text here.	The sentence has been clarified as part of the substantially revised text: it is a key value judgement whether the climate outcome of interest is temperature change relative to a reference level, or if the climate outcome of interest is temperature change due to an emission compared to the absence of that emission. GWP or GTP are not intended to capture warming since a specific date, but warming from an emission relative to the absence of that emission. We also clarified in the text that the dependence of the GWP and GTP on the time horizon is a key problem with their universal use.	Frame	Dave	University of Wellington	New Zealand

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
35555	20	32	20	34	The statment that GWP* incoporates 'key value judgements' is not correct in this context of accuracy in measurement of long term temperature outcomes. The only implied 'value judgement' is the self-evident one that it is better to measure long term temperature outcomes in periods relevant to the Paris Agreement as accurately as possible. Discussion of 'value judgements' is therefore not relevant in this section of the text.	The sentence has been clarified as part of the substantially revised text: it is a key value judgement whether the climate outcome of interest is temperature change relative to a reference level, or if the climate outcome of interest is temperature change due to an emission compared to the absence of that emission. GWP or GTP are not intended to capture warming since a specific date, but warming from an emission relative to the absence of that emission. We also clarified in the text that the dependence of the GWP and GTP on the time horizon is a key problem with their universal use.	Macey	Adrian	Victoria University of Wellington	New Zealand
26285	20	25	20	35	The ongoing discussion on pages 23 and 24 should be reflected to this paragraph. I believe the policy impolications of GWP* is important especially for WG3.	Accepted with modifications; the discussion has been restructured to more clearly separate metrics that measure the contribution of future emissions to future climate change, compared to metrics that capture the effects of both historical and future emissions on future climate change. GWP* belongs mostly to the latter group.	Katsumasa	Tanaka	Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CEA, FRANCE; National Institute for Environmental Studies (NIES), JAPAN	France
28489	20	25	20	35	I think a better explanation of the step versus pulse issue could be made here. i.e. that the time evolution of temperature change due to a sustained emission of a SLCP, more closely resembles the temperature change of a pulse of CO2, than does a pulse emission of an SLCP. It is noteable that this box does not include a figure, but perhaps one illustrating this (it could be purpose-built or use a figure in Allen et al. 2016?) would explain the rationale better.	A figure has been added to better explain a range of issues noted by various reviewers.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
32159	20	27	20	35	I am not sure if using 'step-change' to label GWP* is very helpful (also on p24). In particular because the use of GWP* for policy putposes outlined in Cain et al 2019 has 2 terms, one which is like a 'step-change' but the other is a 'pulse'equivalence, essentially. It's an empirically derived definition, which is designed to work in mitigation scenarios over the near future (RCP 2.6, 4.5, 6) for methane. I guess it's a judgement call as to whether this means it hasn't been tested in 'diverse scenarios' yet - I am unaware of how much different mitigsation scenarios vary in terms of their methane mitigsation in comparison to those tested in Cain et al 2019.	Accepted with modifications; given the relative weighting of the step-change and pulse emission terms in Cain et al (0.75 vs 0.25) we still consider that GWP* is primarily a step-change metric - it is the key reason why GWP* is able to represent declining temperatures under a scenario of rapidly declining emissions. But we have expanded the text (in the Appendix) to better explain the mixed nature of GWP* as developed in Cain et al and applied further in Lynch et al.	Cain	Michelle	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
26283	20	35	20	37	I found this sentence a bit confusing because earlier in this box, it is stated "By contrast, the dynamic GTP compares emissions based on the contribution they would make to warming in the year that temperature is expected to peak in a given mitigation scenario." Perhaps, this means that the dynamic GTP was applied to an assumed period of temperature stabilization (without overshoot), but overshoot was generated in the outcome as a result of the use of dynamic GTP. I am not sure if this is correct, but this sentence needs to be expanded for clarification, if needed.	Accepted and clarified; many economic modelling studies that actually tested dynamic GTPs used the year 2100 as target year, not the actual temperature peak year.	Katsumasa	Tanaka	Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CEA, FRANCE; National Institute for Environmental Studies (NIES), JAPAN	France
26281	20	38	20	38	The use of MGTP should be avoided. This acronym was used to define a different metric by Gillett and Matthewss (2010, 10.1088/1748-9326/5/3/034011), which is equivalent to iGTP.	No longer relevant: the table no longer presents th CGTP following comment from a WGI reviewer that this is not comparable to the other metrics.	Katsumasa	Tanaka	Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CEA, FRANCE; National Institute for Environmental Studies (NIES), JAPAN	France
45133	20	36	20	40	The table compares GWP100 with GTP20 and others while GWP20 may also be added with discussion. Currently, GWP20 is only mentioned in line 36 of page 22 of Chapter 2 while there are is scientific literature that uses GWP20.	Taken partially into account: the revised text notes that GWP20 is also used in some publications. However, WGI is not providing updated GWP20 values and hence we are unable to include them in the table.	Kilkis	Siir	The Scientific and Technological Research Council of Turkey	Turkey
28659	20	36	20	41	MGTP is not directly comparable to the other numbers, and at present this will not be obvious to most readers. Delete columns.	Accepted	Frame	Dave	University of Wellington	New Zealand

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
26289	20	43	20	43	Please fix the reference.	Accepted, references have been cleaned up.	Katsumasa	Tanaka	Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CEA, FRANCE; National Institute for Environmental Studies (NIES), JAPAN	France
47645	20	38			MGTP not defined explicity	No longer relevant: the table no longer presents th CGTP following comment from a WGI reviewer that this is not comparable to the other metrics.	Slade	raphael	Imperial College	United Kingdom (of Great Britain and Northern Ireland)
6909	20	40			Box 2.2 Table 1: GWP20 should be included in the table since it is suggested to be important on page 22, line 36	Rejected; we are using values based on the AR6 WGI assessment, which does not provide GWP20, hence we are unable to include it.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
35849	21	2	21	7	There has been a constant discussion during the UNFCCC negotiations as which is better GWP or GTP, and which method could present their emissions better? Although a lot of clarification is given, it is difficult to understand which one to actually use. This clarification will help countries decide what is good for them, even though GWP seems better for Paris Agreement. Or how GWP* can change national emissions. I am not sure if this should be expected from the revised guidelines.	Taken into account; the box has been revised, and reduced in size to focus on key policy relevant conclusions, with technical details and supporting assessment provided in Appendix B. We hope that those revisions more clearly bring out the policy goals that are best served by the different metrics.	Gupta	Himangana	Institute for the Advanced Study of Sustainability, United Nations University, Tokyo	Japan
9651	21	8	21	9	Section 3.6.2 in Chapter 3 of IPCC WG3 AR5 (i.e., the last IPCC AR) summarized the state of knowledge on discounting and the applicability of the simple Ramsey rule and extensions. Table 3.2 also consider long-term social discount rates between from the literature between 1.4 and 16 percent. Two new contributions to the literature I) find larger consensus on the value of the long-term social discount, and II) questions the applicability of the simple Ramsey rule. I think it is important to highlight these more recent contributions. The key normative/ prescriptive (relating directly to Table 3.2. in the previous IPCC AR) is: Drupp, Moritz A., Freeman, Mark C., Groom, Ben, and Frikk Nesje (2018), Discounting Disentangled. American Economic Journal: Economic Policy 10(4), 109-34. Webpage: http://www.aeaweb.org/articles?id=10.1257/pol.20160240 Abstract: The economic values of investing in long-term public projects are highly sensitive to the social discount rate (SDR). We surveyed over 200 experts to disentangle disagreement on the risk-free SDR into its component parts, including pure time preference, the wealth effect and return to capital. We show that the majority of experts do not follow the simple Ramsey Rule, a widely-used theoretical discounting framework, when recommending SDRs. Despite disagreement on discounting procedures and point values, we obtain a surprising degree of consensus among experts, with more than three-quarters finding the median risk-free SDR of 2 percent acceptable. The key positive/ descriptive contribution is: Giglio, Stefano, Maggiori, Matteo , and Johannes Stroebel (2015), Very Long-Run Discount Rates. Quarterly Journal of Economics 130(1), 1–53. Webpage: https://doi.org/10.1093/qje/qju036 Abstract: We estimate how households trade off immediate costs and uncertain future benefits that occur in the very long run, 100 or more years away. We exploit a unique feature of housing markets in the United Kingdom and Singapore, where residential property ownership takes the form of either leaseholds or freeholds. Leaseholds are temporary, prepaid, and tradable ownership contracts with maturities between 99 and 999 years, while freeholds are perpetual ownership contracts. The price difference between leaseholds and freeholds reflects the present value of perpetual rental income starting at leasehold expiration, and is thus	Noted; while relevant, there is no literature to our knowledge that tested interactions between non-Ramsey discounting rules and GHG metrics. A sentence has been added to point to the evolving picture on long-term discount rates.	Nesje	Frikk	Heidelberg University	Germany

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
27525	21	8	21	18	This discussion implicitly assumes a linear relationship between temperature and damage. This is contrary to the Paris Agreement which is framed in terms of temperature limits - i.e. zero damage below a limit and infinite damage above. Similarly for UNFCCC which discusses levels of GHGs to avoid dangerous climate rather than mininising a linear damage. Such a distinction needs to be discussed prominently here, as this is a completely different framework to damage potentials and discount rates.	Rejected, but text modified to clarify. We disagree that the discussion implicitly assumes a linear damage function, as the text explicitly notes the dependence on assumptions about the damage function. We also disagree that the Paris Agreement implies zero damages below the temperature limit - otherwise there would be no support necessary for adaptation. This is also inconsistent with the WGII assessment which clearly outlines damages occurring at current warming levels and for warming below 1.5 degrees. We edited the text to make this more clear.	Collins	William	University of Reading	United Kingdom (of Great Britain and Northern Ireland)
28495	21	8	21	18	It may be my economic ignorance, but there is a whole para on the GWP/GDP equivalence here and nothing equivalent on the GTP/cost effective equivalence. But it seems that much of the discussion on this page (e.g. abatement costs on line 32 and cost-minimisation on line 36) are in the cost-effective context. If cost-effectiveness is the more common policy framework, then the discussion needs to be targetted at this	Accepted; the discussion of GTP has been extended (in the Appendix) to bring out its correspondence with a cost-effectiveness approach (provided that a dynamic GTP is used that is focused on the presumed/targeted year in which temperature peaks).	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
14605	21	24	21	25	Even more informative would be to also provide a point of reference of where these kind of discount rates are applied in society, for example, for long-term infrastructure investments, planning purposes, etc.	Accepted and used in revision of this text, also in light of comment 9651.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
5181	21	25	21	25	Section xxx should be deleted or corrected.	Accepted, to be consistent with Chapter 3 SOD.	Alataş	Sedat	Aydın Adnan Menderes University	Turkey
28497	21	30	21	31	I need to question this "now very high confidence" - in fact the Smith et al. study adopted the FAR/SAR value for GWP(100) of methane of 21, which is much smaller than the Table 1 value here, and the text leaves it hanging what would happen if a higher than GWP100 value is used (even though reading Smith et al. it is clear that higher is worse, which is what we have, as the current GWP100 is much higher than 21). It is also striking that Smith et al state "the results were more varied under a lower methane index [i.e. lower than 21], with policy costs ranging from 23 % higher to 1 % lower". This is not in line with the "very high confidence" given here, nor is the "very high confidence" strengthend by the fact that Smith et al. only looked at three "values" (the then GWP20, GWP100 and GWP500). Similar Reisinger "only" looks at GTP100 and what is now called the dynamic GTP and use the AR4 GWP100 for methane of 25, again well short fof the current value. Hence I feel strongly that this paragraph needs reconsidering, and placed in the "modern context" and also needs to avoid the impression that systematic studies of varying the methane value were performed in those studies. They werent. Very selective alternatives were used, and it is hard to understand (again in the modern context) why a GTP100 would ever be used. It may be that the more recent studies are more systematic (I am only passingly familiar with them), but using these two older papers as buttresses to this high confidence seems inappropriate.	We have reviewed in detail the assumptions made in the full set of studies cited in response to the comment. The more recent studies have indeed taken a more systematic look; reference to earlier studies is provided only to demonstrate that recent studies haave strengthened, rather than changed the picture that was only emerging at the time of AR5 literature. The text has been mofidied to make clearer that the two older papers are not the core foundation for the "very high confidence" conclusion, only the starting point of a now much more substantive body of literature	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
28499	21	32	21	32	I cant understand, in the modern context, why anyone would use the GTP100, when peak temperatures are (hopefully) more likely reached in 30 to 60 years. I suggest a more appropriate value is used here, to avoid a suspicion that you are choosing a value to justify GWP100.	Noted; we are stuck with the values used in scientific literature (and most studies used GTP100 as an example of a metric that gives a systematically lower value to CH4 abatement than GWP100), but we have modified the text to clarify that there is little theoretical foundation for using GTP100 as part of a mitigation strategy.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
14607	21	26	21	37	This paragraph, which provides a statement with "very high confidence", should further reflect on how the scenario design choice of aiming for a temperature goal in 2100 only and allowing for an unconstrained overshoot before affects these insights. Recently, a new, more Paris Agreement aligned scenario has been proposed (see ref [1] below) which is now also being implemented in integrated assessment models and used as a framing concept in Chapter 3 of the AR6 WG3 assessment. This can change the confidence attributed to this statement. [1] Rogelj, J., Huppmann, D., Krey, V., Riahi, K., Clarke, L., Gidden, M., Nicholls, Z., Meinshausen, M., 2019. A new scenario logic for the Paris Agreement long-term temperature goal. Nature 573, 357–363. https://doi.org/10.1038/s41586-019-1541-4	Accepted with modifications; there is no literature that evaluates the impact of different metric choices under the scenario architecture outlined in Rogelj et al 2019. We clarify that the confidence assessment is based on whole-of-century cost minimisation studies and may not apply if a more nuanced approach is taken (which would imply a step-wise cost-minimisation for different policy objectives over time).	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
38769	21	38	21	38	Which temperature goal does the Paris Agreement prescribe? There are two temperature goals. Moreover, the word “prescribe” is very strong and should be re-worded to remain policy-neutral.	There is only one, complex temperature goal in the Paris Agreeement. We have removed the word "prescribe", but note that it is not the IPCC that prescribes this goal but the Paris Agreement itself.	Reyes	Julian	Personal Capacity	United States of America
28501	21	39	21	39	Mallapragada and. Mignone, 2019 only seem to discuss the GWP. Is this the correct reference for the point being made here?	Accepted, they don't directly address dynamic GTP; replaced with reference to Tol et al 2012.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
37149	21	38	21	47	The Paris Agreement goals relevant for mitigation comprise Article 2 and 4 that need to be interpreted in conjunction and are thus more than just a temperature goal (see e.g. Schleussner et al. 2019, Table 1). In order to evalute the temperature goal including the two referenced temperature levels, an assessment of the implications of the warming potential underlying the balance language in Article 4 (GWP100 based on the AR5) is decisive.	The text has been modified to clarify this. Most model studies evaluating the role of GHG metric choices used only a temperature target, and no additional constraint on when emissions would need to reach net zero. We revised the text to clarify that the existing studies have not explicitly sought to accommodate all provisions in the Paris Agreement.	Schaeffer	Michiel	Climate Analytics	Netherlands
28503	21	40	21	47	I found this discussion quite weak and confusing in the context of the previous paragraph. Is there a confidence level associated with the use of the dynamic GTP? The sentence starting "However …" (line 43) is unhelpful - I am sure the results are dependent on assumtptions, that is the nature of the beast, but it seems that the consensus remains that a dynamic GTP could be more cost-effective if implemented properly. Surely that is an important message?	The text has been revised but not changed fundamentally; the point is that whether the dynamic GTP offers an advantage over GWP does depend on the factors listed, and there is little value from a policy perspective to offer a confidence judgement based on first principles only. However we have clarified that based on first principles, a dynamic GTP is more cost-effective than GWP100.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
26291	21	43	21	47	I think that it would be helpful if it comes more close to what are the key messages that can be derived from these post AR5 literature. Considering the uncertainties reported by these new studies, what is the range of cost reduction by applying dynamic GTP relative to the cost of usingg GWP100? How does the policy insight influence the cost calculation?	Accepted; the text has been updated to provide a more detailed summary of the results, also to address concerns by another reviewer about the confidence level of the conclusions in the preceding paragraph.	Katsumasa	Tanaka	Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CEA, FRANCE; National Institute for Environmental Studies (NIES), JAPAN	France

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
28661	21	1	22	12	This isn't an assessment, it's a defence of the status quo. It is heavily biased towards literature that exonerates GWP. Physically, it ignores the fact that substituting SLCP reductions for CO2 reductions will lead to wa warmer world: "Eventual mitigation of SLCP can make a useful contribution to climate protection, but there is little to be gained by implementing SLCP mitigation before stringent carbon dioxide controls are in place and have caused annual emissions to approach zero. Any earlier implementation of SLCP mitigation that substitutes to any significant extent for carbon dioxide mitigation will lead to a climate irreversibly warmer than will a strategy with delayed SLCP mitigation. SLCP mitigation does not buy time for implementation of stringent controls on CO2 emissions" - see Pierrehumbert 2014. It also ignores GWP* here, even though the Allen et al 2018 paper shows clearly that GWP* gives a better global fit to the warming contributions of different gases under strong mitigation (i.e. Paris) scenarios. I think the text would improve if the circle of authors were widened. More generally, Pierrehumbert again: "if the prime climate protection goal is to limit peak warming, then early SLCP mitigation is pointless, because in no case does early SLCP mitigation significantly reduce the peak warming. The calculation does show, however, that eventual SLCP mitigation helps trim the magnitude of the peak warming."	Partly taken into account; text has been modified to clarify. The reviewer is incorrect in his assertion that substituting SLCF reductions for CO2 reductions will result in a warmer world, at least for the 21st century. This is evidenced by the fact that GWP100 underestimates the warming from sustained SLCF emissions compared to their CO2-equivalent emissions over the first 100 years after those emissions. Furthermore, SLCF emissions today will still make a substantial contribution to warming a few decades into the future (as evidenced by GTP values substantially greater than zero for time horizons of 10-50 years; see Table and WGI SOD). Hence what is "early" or "later" SLCF mitigation depends strongly on the assumed climate mitigation goal. In 1.5 degree scenarios, peak warming is only about 30 years away, and in below-2 degree scenarios, 50 years. The section ignores GWP* because it is explicitly about pulse emission metrics, and GWP* is not a pulse emission metric.	Frame	Dave	University of Wellington	New Zealand
27527	21	26	22	12	These paragraphs seems to contain the central argument of this box, that the costs are not too far out using the GWP100. There needs to be further discussion of the wider uses of climate metrics beyod cost optimisation - for instance contributions towards cumulative carbon budgets "trilliionth tonne" for which GWP100 is not applicable.	Accepted - this is reflected in the revised introduction and modified discussion of other uses of GHG metrics.	Collins	William	University of Reading	United Kingdom (of Great Britain and Northern Ireland)
28673	21	1	24	21	Overall this Box reads like a passionate defence of GWP and like a very partial, selective attempt to damn GWP*. It is of poor quality, scientifically, and its arguments about value judgements are unpersuasive (at leas tto this philosophy graduate) because they are so selectively applied (inheriting this from Rogelj & Schleussner 2019). A better idea would be to discuss warming, equity, and so on in light of emissions-equivalence and warming-equivalence, and show the effects historically, in the next few decades, and in the long term (perhaps under the SSPs). But something has to change here, because at the moment it looks like a mainly European attempt to secure as much warming space as possible for Europe, and to forestall any attempt to have an open debate about gases, metrics, warming and fairness.	The text has been modified to clarify the line of arguments. Also, the introduction to the box has attempted to better differentiate the key issue of whether the quantity of interest is the contribution of future emissions to future warming, or the contribution of both historical and future emissions to future warming, and the associated different policy goals and relevant notions of fairness. A figure has been added to illustrate those differences and the ability of different metrics to reproduce the different quantities. We are unable to trace the basis for the reviewer's impression that the box looks like a European attempt to secure as much warming space as possible for Europe.	Frame	Dave	University of Wellington	New Zealand
1969	21	28		46	In the both of the line 28 and 46, the reference (Ekholm et al. 2013) should be without the letters a and b. The literature references (Ekholm et al. 2013a) and (Ekholm et al. 2013b) are the same reference.	Accepted, references have been cleaned up.	Savolainen	Ilkka	Tech.Res.Ctr. of Finland VTT, emeritus research professor	Finland
1275	21	19			directly from where? Be specific in this statement	Accepted, text has been revised to make the the methodology of Shindell et al clearer.	Anoruo	Chukwuma	University of Nigeria, Nsukka	Nigeria
28505	22	8	22	8	I am not really clear what the authors class as a "simple and transparent metric" - does dynamic GTP qualify? I am also not sure that the previous paragraphs support the statement endorsing the use of GWP100 (to high confidence)	As noted in the preceding paragraph, the issue is not whether a dynamic GTP is simple and transparent, but that it doesn't actually offer consistently lower global mitigation costs once basic real-world constraints are taken into account. Revisions to the preceding paragraph hopefully make this clearer.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
38771	22	8	22	8	Meet which temperature goal of the Paris Agreement? 1.5 or 2 deg C? Please be specific.	There is only one, complex temperature goal in the Paris Agreeement. We have edited the text to make this clear.	Reyes	Julian	Personal Capacity	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
26293	22	8	22	10	AR6 cycle started before the Paris Agreement started, so the authors interpret many pre-Paris literature from the Paris Agreement perspective. Before the authors make this conclusion, I argue that they should touch on Tanaka and O'Neill (2018, 10.1038/s41558-018-0097-x), which actually tested GWP100, GWP20, and GTP100 in the Paris Agreement setting. This work imposed the net zero GHG target using GWP100, GWP20, and GTP100 in a dynamic cost-effective setting and looked into the temperature outcome. The paper shows that, when such emission target needs to be met by 2060, GWP100 implies declining temperatures after peaking around 2C. GTP100 leads to stable temperatures around 2C. GWP20 makes the net zero goal unachievable under the assumptions in the study. Fuglestvedt et al. (2018, 10.1098/rsta.2016.0445) also shows a related outcome from a different scenario-based approach). But the Tanaka and O'Neill study did not make a strong conclusion regarding the choice of metrics by acknowleding that more studies are needed to recommend metrics for the Paris Agreement. I should also note that this study uses economic costs to derive cost-effective pathways, but did not directly use the costs as a criterium to evaluate the outcome (i.e. it focuses on the consistency between the emission and temperature outcomes). So I agree with the conclusion made in this statement, but I think that it needs more discussion like above before coming to this conclusion.	Accepted and thanks for the constructive comment. The discussion of the available literature has been extended to more clearly bring out the assumptions and limitations of the existing literature on metrics.	Katsumasa	Tanaka	Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CEA, FRANCE; National Institute for Environmental Studies (NIES), JAPAN	France
31919	22	8	22	10	Suggest you insert: "Combined pulse/flow metrics such as GWP* (Cain et al, 2019) or CGWP (Collins et al, 2019) necessarily reproduce the temperature impact of emissions over a broad range of timescales much better than any pulse metric because they reflect the different behaviour of short-lived and cumulative climate pollutants." This statement is clearly supported by all the literature available, consistent with our understanding of the underlying physics, so I suggest it can be made with high confidence, and is clearly policy relevant.	Rejected, as this is not relevant to the discussion here. There is no literature that demonstrates how to use the GWP* metric in economic modelling studies, let alone that it would allow meeting a temperature limit at lower global cost than GWP100. There is no theoretical justification that it would do so because it mixes the climate effects of historical emissions with those from future emissions, whereas minimising mitigation costs is concerned with the climate effect from future emissions only. Text earlier in the revised version of this box seeks to signal this.	Allen	Myles	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
32153	22	8	22	12	Is there an element of circualr logic to this? IAMs were designed to use GWP100 and therefore the use of GWP100 works best.	Rejected; while most IAMs use GWP100 in practice, they are not *designed* to use only that metric (rather, most rely on setting a constraint on cumulative CO2-eq emissions, but the CO2-equivalence can be determined using a range of different metrics). The studies cited in the earlier paragraphs explicitly used a range of alternative metrics (GWP with different time horizons, and static or dyamic GTP). Those studies show that different metrics do change the costs (with GWP100 and dynamic GTP being most cost-effective); they also change the timing of SLCF mitigation somewhat but don't change the overall SLCF mitigation path fundamentally. Results using other models (e.g. Manne and Richels 2001; Johansson 2012) show similar results in terms of cost-minimising metrics to IAMs.	Cain	Michelle	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
37151	22	8	22	12	The whole box is giving the idea that the metric underlying the Paris Agreement is 'unknown'. However, it is important to acknowledge that just because it is not explicitly mentioned, it cannot be assessed. I would argue that it is very clear from the policy context that the PA was designed based on GWP100. A detailed background on this is provided in Schleussner et al. (2019).	Rejected; the purpose of this box is not to provide an exegesis of the intent and knowledge of policymakers negotiating the Paris Agreement, but to assess ex post what we know about the ability of GHG metrics to deliver on the climate outcomes that the Paris Agreement has formulated. However, in the revised box we more explicitly clarify to what extent the Paris Agreement has committed to using GWP100.	Schaeffer	Michiel	Climate Analytics	Netherlands
36435	22	16	22	16	Abbreviate here (and also already earlier)to 'IPPC'	Accepted, references have been cleaned up.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
28663	22	21	22	21	The NZ inventory is not "dominated" by enteric methane emissions. In regular English use, domination would imply >>50%; yet enteric methane is ~35% of NZ's inventory. That's misleading, and a long way from dominance. Suggest rewording to something like "where the inventory has, for a developed country, a high proportion of enteric methane emissions"	Accepted with modification; the proportion of methane is also high for most developing countries.	Frame	Dave	University of Wellington	New Zealand
44479	22	20	22	23	You should explicitly mention in which ways this is reflected in the design of New Zealand's net zero target	This study did not look at a split-gas target as the split-gas target was introduced three years after this study was completed. However we do now clarify that this is for an all-gases target.	Geden	Oliver	German Institute for International and Security Affairs	Germany
26295	22	25	22	30	In the context of the coal vs gas debate analyzed in Tanaka et al. (2019, 10.1038/s41558-019-0457-1), the outcome is actually sensitive to the choice of metrics. To be more precise, the outcome is robust based on the way how the study applies and interprets multiple metrics (i.e. GWP100, GTP100, GWP20, and GTP20). On the other hand, the outcome becomes sensitive to other assumptions (e.g. CH4 leakage rate and location) if it is based on the way how some other studies use multiple metrics (i.e. GWP100 and GWP20) (Ocko et al. 2017, 10.1126/science.aaj2350; Fesenfeld et al. 2018, 10.1038/s41558-018-0328-1). This partly explains why the view on the climatic impact of shale gas boom has been divided (Fig. 3 and Table 1 of Tanaka et al. (2019)). The Tanaka paper can be probably better placed with the Edwards papers in line 26.	Accepted	Katsumasa	Tanaka	Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CEA, FRANCE; National Institute for Environmental Studies (NIES), JAPAN	France
28507	22	30	22	30	Need to rewrite this, as the climate impact of aviation is likely independent of metric (!) - does this mean the perceived impact of present and future emissions?	Accepted and rewritten to clarify along the lines suggested by the reviewer	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
26299	22	37	22	38	I suggest Cherubini et al. (2016, 10.1016/j.envsci.2016.06.019) as a highly related literature on this debate.	Accepted	Katsumasa	Tanaka	Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CEA, FRANCE; National Institute for Environmental Studies (NIES), JAPAN	France
26297	22	34	22	40	I disagree with this paragraph. The choice of a single metric has not seen a unaminous consensus in science. But the same still goes for the choice of multiple metrics. Ocko et el. (2017) writes "Acknowledging the dominant role of GWP in the policy arena, our proposal abandons the quest for an alternative metric because there is a simpler way to prevent confusion and focus debate on the temporal trade-off: report GWPs based on the 20- and 100-year time scales together as an inseparable slashed pair." On the other hand, Levasseur et al. (2016, Global Guidance for Life Cycle Impact Assessment Indicators, ed R Frischknecht and O Jolliet (Paris, France: UNEP) pp 59-75) suggested GTP100 for long-term impacts and GWP100 for short-term impacts, with GWP20 for sensitivity analysis. Furthermore, Tanaka et al. (2019, 10.1038/s41558-019-0457-1) argues "In general, the commonly used combination of GWP20 and GWP100 is not adequate in addressing long-term climate stabilization as called for by the Paris Agreement." The debate is still open regarding which multiple metrics to use.	Taken into account; the revised text seeks to be more nuanced along the lines suggested by this review comment	Katsumasa	Tanaka	Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CEA, FRANCE; National Institute for Environmental Studies (NIES), JAPAN	France

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
28665	22	43	22	45	" Such approaches avoid value judgements inherent in metrics but cannot avoid the need for judgements about time horizons and reference levels in the interpretation of results." I think this is probably wrong. Metrics involve embedding judgements, whereas treating gases separately or modelling the effects of each separately does not. What it does do is push questions about priorities to the policy design level, but that's different from embedding judgements. The text here should be clarfied to make it clear that treating species separately (as we do with the carcinogens cigarette smoke and asbestos) allows explicit, targeted treatment of pollutants, while bundling things together in a metric encodes strong value judgements that users and policymakers may not be aware of, if they treat those metrics as unproblematic (as the preceding text in the box vigorously encourages them to do).	Taken into account in revisions. The point remains that even if one treats gases separately, policymakers still need to make decisions how much resource to allocate to abatement of individual gases, as part of an overall climate change policy portfolio (in contrast to cigarette smoke vs asbestos, where decisions do not fall within the same immediate policy portfolio; also in those contexts, stakeholders often disagree vigorously whether sufficient and equal attention is being paid to different pollutants, based on their different value judgements). So even if climate policy targets gases individually, it still needs to make value judgements about how much we care about multi-century vs decadal outcomes from different gases, and how much we care about the contribution from future emissions vs legacy warming from past emissions in setting future emission targets. The revised text seeks to be clearer about these issues.	Frame	Dave	University of Wellington	New Zealand
44481	22	46	24	21	I can see the reasons why you have one section on GWP/GTP and one on GWP*, but if you were to follow the proposed "political relevance is more important than the scientific relevance" rule, then it would be better to integrate the considerations on GWP* into the global & country/sector differentiation used for GWP/GTP, or, if this is impossible, at least use this differentiation in the GWP* section as well	Taken into account in the narrative through this box. We now emphasise more clearly that an important distinction that underpins the use of GWP* in the literature to date, as compared to GWP or GTP. The latter metrics focus on the effect of an emission relative to the absence of this emission (i.e. against a prescribed reference background), whereas GWP* as used in the literature to date considers includes the effect of historical emissions when describing the (additional) warming from future emissions. While GWP* can be used in principle to focus on the effect of future emissions only, the use of GWP* for this purpose in the literature has been very limited.	Geden	Oliver	German Institute for International and Security Affairs	Germany
14609	23	1	23	2	It would be logical to first indicate the (most) appropriate use of GWP and GTP metrics and then highlight that when used otherwise they do not perform that well. The use of the word "problematic" is value laden, and hence problematic in itself. Instead, the assessment should neutraly (yet clearly) state the strengths and weaknesses of the various GWP and GTPs. I suggest rewording this first sentence to: Metrics like GWP and GTP intend to reflect the relative climatic effects of emissions (either forcing or warming) occuring in a given year for which they provide a good scientific tool. However, this does not provide a strong theoretical basis for a close relationship between cumulated CO2-equivalent emissions calculated with these metrics and total global mean temperature increase, because short-lived greenhouse gases do not accumulate in the atmosphere as is the case with CO2 (Ref AR6 WG1 Chapter 5, Section 5.5).	Accepted with modifications; the revised box has strengthened the clarification up-front of different policy contexts, and has sought to bring out more clearly what policy purposes best match different metrics.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
36687	23	2	23	5	"warming from each new SLCF..." assumes that all SLCFs are warming; however aerosol increases are estimated to produce net cooling (Chapter 7 Forster et al WG1 SOD)	Accepted; clarified that we're discussing warming from GHGs here not aerosols.	Naik	Vaishali	NOAA GFDL	United States of America
28509	23	8	23	8	After "warming" I suggest adding "until net zero emissions are reached"	Accepted	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
14611	23	6	23	10	This explanation can be made more accurate by first indicating that pulse GHG emissions metrics intend to provide a relative weighting for and then contrast this with their use in a cumulative CO2-equivalence framework.	Accepted as part of the revisions to this text.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
28511	23	8	23	10	I am not sure I agree with this - things like the constant background atmosphere are minor considerations. The prime issue is that converting an SLCP emission to effective (and long-lived) CO2 emissions) means that the temperature effect of those emissions is completely misrepresented. The latter indicates a long-term commitment to more warming, whereas the declining SLCP emission indicates a declining contribution to warming.	Accepted; clarified that we're discussing warming from GHGs here not aerosols.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
38773	23	16	23	16	There are no references to temperature targets in the Paris Agreement. Please use “goal” or “goals”, which are mostly consistent in the other chapters in WGIII and other WG reports.	Accepted	Reyes	Julian	Personal Capacity	United States of America
26303	23	11	23	17	Fuglestvedt et al. (2018) and Tanaka and O'Neill (2018) arrived at the same conclusion independently. But Tanaka and O'Neill (2018) has been published several months before Fuglestvedt et al. (2018) was published. Thus, it is not exactly correct to state "This (the finding) was confirmed by Tanaka and O'Neill (2018)." The order of the mention should be opposite. In addition, I suggest that the authors note that these two studies used different approaches. Tanaka and O'Neill (2018) employed a single model using a dynamic cost-effective approach and directly imposed the net zero GHG target using different metrics in the model to see how the temperature responds. On the other hand, based on my understanding, Fuglestvedt et al. (2018) used a databse of existing emissions scenarios generated for many different purposes (but none directly designed to investigate metrics) and analyzed the temperature response from the point of zero emissions defined by different metrics.	Accepted as part of the revisions to this text.	Katsumasa	Tanaka	Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CEA, FRANCE; National Institute for Environmental Studies (NIES), JAPAN	France
37153	23	11	23	17	This section is completely oblivious to the possibility that the decline in temperature is intended under Article 4. In this context, it is important to highlight that the PA is not about temperature stabilization and does not preclude in any way, at which temperature warming should be ‘stabilized’. Through declining temperatures, 1.5°C is established as the long term limit (See e.g. Schleussner et al. (2019) for a detailed discussion).	Accepted	Schaeffer	Michiel	Climate Analytics	Netherlands
14613	23	14	23	17	Suggested rephrasing: "This was confirmed by Tanaka and O’Neill (2018) who showed that if maximum (or peak) warming is kept below a temperature limit with strictly no overshoot, net zero GHG emissions based on GWP100 would not be a necessary condition to achieve this target as net zero GHG emissions occur after net zero CO2 emissions are achieved and only affect the temperature evolution after the peak. "	Accepted with modifications (net zero GHG emissions do not just occur later but do not occur at all in a scenario that has no overshoot).	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
36437	23	17	23	17	Overshoot of what?	Added 'temperature'	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
14615	23	18	23	24	This very high confidence statement is poorly phrased and biased against pulse emission metrics. Th meaning of "applying pulse emission metrics to time series of emissions extending over many decades" is ambiguous. One can apply GWP-100 to time series of GHGs and depending on how these time series are used thereafter, the estimated temperature outcome will be more or less precise. This statement should define the use and context in which pulse emission metrics provide less robust outcomes. Its bias against pulse emission metrics lies in that also the opposite is true for step-change metrics like GWP*: achieving a specific annual target with step-change metrics (like net zero GWP* emissions in a given year) provides a very poor constraint on the actual temperature outcome and therefore does not provide a robust way for achieving specific temperature outcomes.	Accepted with modifications; we made clear that the issue arises if CO2-equivalent emissions are assumed to result in strictly cumulative temperature outcomes. We also added a graph that clarifies the extent to which using GWP100 to a time-series of CH4 emissions both over- and under-estimates actual warming at different times.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
31921	23	21	23	24	This would be a good point to stress that it is good practice (and essential to keep stock of progress to a long-term temperature goal) to report emissions of long-lived (cumulative) climate pollutants and short-lived clmate pollutants as two separate aggregate quantities, not mashed together into a meaningless pulp.	Accepted with modifications (net zero GHG emissions do not just occur later but do not occur at all in a scenario that has no overshoot).	Allen	Myles	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
28667	23	28	23	31	The text here is doing its best to argue there is no problem here. In fact, 0.17 is a third of the remaining distance to 1.5C. A better way of interpreting this is that GWP could, if used to report emissions, imply errors in the temperature implications of a global portfolio of gases that look Paris-compliant by CO2e standards, be out by up to 33% in terms of the actual warming. This is not "non-trivial". It is large, and you shouldn't try to obscure it. The point that current pledges amount to 3C of warming is ironic: this is overwhelmingly because of insufficient action on fossil CO2. The text should either state that, or remove the reference, which reads like context designed to minmise the flaws in GWP.	Accepted	Frame	Dave	University of Wellington	New Zealand

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
41103	23	34	23	34	Regarding "step-change metric": step for the non-CO2 and pulse for the reference gas CO2. Check consistency of formulation with WGI.	Accepted and revision has been cross-checked with WGI SOD.	Fuglestvedt	Jan	CICERO	Norway
28513	23	32	23	35	Collins et al. 2020 10.1088/1748-9326/ab6039 is also important here	Added 'temperature'	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
31927	23	34	23	35	"Constructs an equivalence…" is rather opaque. Given there is much confusion around GWP* and a general sense that it is very complicated, I suggest you replace with "GWP* equates CO2-warming-equivalent emissions of a SLCP in a given year with CO2-equivalent emissions of that SLCP (calculated using GWP100) in that year, multiplied by a factor of 4, minus CO2-equivalent emissions in the year 20 years previously, multiplied by a factor of 3.75. (CO2-we(t) = 4xCO2-e(t) - 3.75xCO2-e(t-20); Cain et al, 2019)"	Taken into account; the text offered by the reviewer does not strike us as simpler to understand for most non-experts. But we have attempted to give a simpler qualitative presentation of GWP* followed by the formula from Cain et al (which leaves it open whether to use 20 years or some other interval to calculate the change in emission rate). Our understanding is that the literature has not offered a phsyics-based reason why to use 20 years specifically, even though this choice could have major implications in specific policy contexts. So keeping this open seems more consistent with the literature for now, even though Lynch et al explicitly adopted 20 years (but again without a physics-based derivation).	Allen	Myles	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
14617	23	32	23	38	This description of the strengths of GWP* should also include a balanced discussion of its weaknesses. Strengths include that cumulative CO2-equivalent emissions expressed through GWP* show a close relation to the total amount of global warming. Weaknesses are that single-year targets in GWP* link very poorly to the temperature outcome and net zero GWP* emissions milestones are potentially meaningless with regard to which specific absolute temperature level is ultimately achieved.	Accepted with modifications; we made clear that the issue arises if CO2-equivalent emissions are assumed to result in strictly cumulative temperature outcomes. We also added a graph that clarifies the extent to which using GWP100 to a time-series of CH4 emissions both over- and under-estimates actual warming at different times.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
27529	23	32	23	38	Note Collins et al. 2020 Environ. Res. Lett. 15 024018 formally define the combine step-pulse equivalences of metrics.	Accepted	Collins	William	University of Reading	United Kingdom (of Great Britain and Northern Ireland)
31935	23	37	23	38	Misleading: there have been only two variants (the first had both coefficients 5, revised to 4 and 3.75, a much smaller revision than the many revisions that have been made to GWP100 alone), and the potential need for a flow contribution was noted in the Allen et al papers. The scenario-dependence is much lower than that of GWP100. Suggest delete "although...": it doesn't really achieve anything other than vague disparagement.	Taken into account; we do consider the addition of a cumulative effect a significant evolution compared to how the GWP* was introduced in the original 2016 paper. The scenario dependence shown in Cain et al 2019 is non-trivial, as the co-efficient for the cumulative component under RCP2.6 is more than 50% greater than under RCP4.5. However, it is not our intention to disparage GWP* and we have revised the wording to be clearer about this.	Allen	Myles	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
35557	23	37	23	38	"different formulations" is misleading. The later paper presents a refinement of the oriignal formula giving greater accuracy.	Taken into account - it's really an evolution (because the later formulation does consider a cumulative warming effect that the original paper excluded).	Macey	Adrian	Victoria University of Wellington	New Zealand
35559	23	40	23	43	This criticism can easil be shown to be factually incorrect by the correct application of GWP*	We are unsure what the reviewer considers to the correct application of GWP* in this context, but we have revised this text in light of other comments from reviewers who co-authored GWP* papers.	Macey	Adrian	Victoria University of Wellington	New Zealand

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
31923	23	42	23	43	This is not true: GWP* makes it clear that both the level and the rate of change of emissions of an SLCP contribute to global temperature change. In contrast, pulse metrics such as GWP100 ignore the very large impact of increasing or decreasing SLCP emissions, making them more ambiguous than GWP*.	Rejected but taken into account in revisions; even in the later formulations of GWP* as in Cain et al and Lynch et al, the CO2-we emission from 1 Mt and 100 Mt CH4 do not provide a good match to the actual warming from those emissions *relative to those emissions not occurring* . But we recognise in the revised text that the later formulations of GWP* do incorporate a component that differentiates those emissions streams, whereas earlier formulations did not differentiate those emissions streams at all.	Allen	Myles	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
31925	23	43	23	44	Using the revised formula of Cain et al (2019) (see comment on line 34-35) shows that these constant emissions would be equated with 7 and 700 MtCO2-we respectively, which would indeed reproduce their warming impact assuming this methane souce started at some point in the last century. A constant methane source that started 2000 years ago is indeed no longer having an impact on global temperature (although switching it off would have a cooling impact).	Accepted with modification. The comment shows that the change from the initial Allen et al papers to the later Cain et al and Lynch et al papers was a non-trivial conceptual evolution (contrary to comment 31935). In addition, the revised formulations give the correct presentation of *additional* temperature relative to those emissions having occurred already over an extended period in the past; they do not give a good representation of the warming due to those emissions compared to the absence of those emissions, or if those emissions started only 20 years ago.	Allen	Myles	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
26301	23	41	23	45	This is just a minor point. A simple climate model allows one to look at the outcome more comprehensively than metrics do. A simple climate model does not impose a fixed perspective, unlike metrics presuming some selected variables and time scales.. Given this, on line 42, I feel that "more comprehensively" is more approapriate than "directly."	Accepted	Katsumasa	Tanaka	Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CEA, FRANCE; National Institute for Environmental Studies (NIES), JAPAN	France
28515	23	42	23	46	This example is entirely spurious. Suddenly, out of the blue, comes a requirement that a metric should not only correctly represent the impact of current emissions on future climate change, but it should encode responsibility for past warming. This is nonsense. The conventional usage of the GWP doesn't do this, so why is this a valid criticism of the GWP*? The future impact of CO2-equivalent emissions (using GWP100) doesnt take into account the cumulative emissions of CO2 prior to that time; two countries could have similar present-day emissions, but quite different cumulative emissions (and hence historical responsibility for warming). The total historical warming effect of the 1 and 100 Mt emissions of CH4 can be quite easily computed and accounted for, if this is required in a policy context, as can the mitigation opportunity presented by reducing those emissions. By contrast, current emissions of CO2 can tell you nothing about historical responsibility.	We do not agree that the example is entirely spurious but have taken the comment into account in revisions to clarify why it is not spurious. The key point is that pulse-based metrics such as GWP and GTP evaluate the contribution of an emission to temperature relative to those emissions not occurring - i.e. without consideration of trends in historical emissions up to that point. Those metrics therefore do provide information on the effect of future emissions but explicitly exclude the effect of past emissions on future climate. GWP*, in sharp contrast, evaluates the effect of future emissions on future climate while explicitly accounting for the (declining) effect of past emissions on future temperature. However, we have substantially expanded and revised the text to make clear that GWP* *could* be used to describe the effect of future emissions relative to the absence of those future emissions - but this is not how the literature on GWP* has tended to apply this metric to date.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
32155	23	43	23	46	This example needs to be put in context of the equivalence with CO2. GWP* brings methane into the same basis as CO2. This equivalent example for CO2 is that net zero CO2 has a different contribution to climate change dependent of the cumulative CO2 emission to date at the time net zero CO2 emissions are reached. e.g. if we reach net zero CO2 emissions having never started buring fossil CO2, we would have virtualy nil global wamring. However if we rach net zero CO2 today we will have had over 1C of warming.It's the same thing, and is why using GWP* is caled CO2 warming equivalent.	Talen into account. The comment is focused on the contribution from historical emissions, but for many policy applications (as the revised box makes clearer) the key question is how much future emissions contribute to climate change, compared to the absence of those future emissions (i.e. how much effort should be placed on abating those future emissions). The benefit over the 21st century of avoiding 100 Mt CH4 is far greater than that of avoiding 1 Mt CH4, and none of the GWP* formulations in the literature to date capture this benefit.	Cain	Michelle	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
28517	23	47	23	47	As far as I can see "fairness" in this context means that countries have to account for the impact of their past methane emissions on temperature but not for their past CO2 emissions. It seems to put large methane emitters at a disadvantage compared to large CO2 emitters, so it is a strange definition of fairness. At the very least the text should say that "Rogelj and Schluessner claim that this raises issues of fairness".	We have revised the text to make clearer that the potential unfairness arises precisely because GWP* bases the CO2-we contribution of future emissions on the level of past emissions.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
28519	23	47	23	47	"grandfathering" - the GWP* (and for that matter the GTP) concept makes clear that there is a big distinction between grandfathering emissions and grandfathering warming. Emissions of methane, say, 50 years ago, have very little impact on temperature today, unlike emissions of CO2. So a clearer definition of grandfathering (and preferably adoption of gender neutral language) would seem appropriate.	Accepted with modifications. We are happy to change the terminology to 'grandparenting' although this term is less widely used. We spell out more explicitly that grandparenting is normally used where the level of a past polluting activity creates an allowance for a future level of a polluting activity. Use of GWP* as suggested in the literature and by various review comments would result in grandparenting of emissions allowances, because the weighting given to a future emission depends on the level of past emissions of the same emitter.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
37155	23	39	23	49	This discussion of the findings of Rogelj & Schleussner (2019) needs to be improved. In the beginning, it correctly states that 'the use of GWP* to inform national or sectoral emission targets has been contested" only than to end with "However, this concern is related to the potential use of GWP* for policy rather than its ability to estimate temperature outcomes." This could merit some streamlining. On a more substantive issue, the core concern of Rogelj & Schleussner is slightly different from what's being presented here. It's is about the fact that the application of GWP* to any but the global level raises fundamental questions about equity and fairness on how to distribute the SLCPs 'stock' in the atmosphere. The point made here is correct, but the distributional issue is broader. Furthermore, GWP* allows for 'negative CO2eq' emission by reducing SLCPs.	Taken into account, we have tried to improve this discussion, but also fundamentally expanded the discussion of different policy context and the degree to which GWP* in different potential uses matches those policy goals.	Schaeffer	Michiel	Climate Analytics	Netherlands

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
28669	23	39	24	2	You should also reference the reply by Cain et al to give a balanced assessment of this discussion. The text here as it stand is not quite right. GWP* accurately reflects warming from when you start using it. If we had national inventory data from 1750, then it could be used to give the resulting warming. In other words, the reference level only arises because the metric starts once emissions were already happening. CO2 emissions are also reported in some cases post 1990 or similar. This also grandparents warming, in exactly the same way, yet RS19 do not seem to have a problem with this. This is why RS19 is a very incomplete discussion of warming/grandparenting - because they apply a responsibility to methane-induced warming that they do not apply to CO2-induced warming. Furthermore, a net zero GWP-based approach also gives rise to equity issues, and in my view these are far more acute and serious. Consider the following simplified example: • There are two countries, Alpha and Bravo. They have jointly signed up to a 1.5°C limit. • Alpha's warming (amounting to 1.4°C, to date) comes entirely from CO2, and Bravo's warming (0.1°C) comes entirely from long-standing rice-paddy methane. • In the next decade, Alpha's journey to net zero CO2 implies another 0.1°C. Bravo, because they emit only methane, are maintaining their long-standing 0.1°C, but are not adding further warming. • To meet their joint commitment, warming must be reduced by 0.1°C, compared to what will happen if both follow their current strategies. On the logic of net zero CO2-equivalence, this responsibility falls entirely on Bravo, because if LLCFs and SLCFs are treated as CO2-equivalent, Alpha has committed to a net zero target while Bravo has not. Bravo's on-going emissions then seem unjustified – surely it would be wrong for Bravo to continue to emit large amounts of methane while Alpha is required to get to zero? Other things equal, this is unfair because it obliges Bravo to undo all its warming, while allowing Alpha to retain all of its. In fact, other things are not equal: LDCs have very high shares ofagricultural methane emissions in their inventories, whereas rich countries have high fossil carbon shares. This compounds the unfairness, because it awards all the warming space to rich countries, especially those which have been in the emissions game for a long time. In other words, Europe gets lots of warming space at Africa's expense. This is a far more serious equity point than those in RS19.	Taken into account in substantive revisions. The reply by Cain et al was not available at the time the FOD was submitted and is included in the revised text. We have also substantially expanded the discusison of the role of metrics with regard to policy applications that focus only on the effect of future emissions, relative to those future emissions not occurring, and the warming from both historical and future emissions.	Frame	Dave	University of Wellington	New Zealand
27531	23	43	24	2	This example of two sources is very misleading. In the example it is the contribution to *past* climate change that differs by two orders of magnitude. The contribution to future climate will of course be zero in both cases (apart from some realisation of hidden warming). This report should focus on the mitigation of future cliimate change, rather than who was to blame for what in the past. A similar argument could be made for CO2, two countries would get equal credit for a 1 Mt reduction in CO2 even though one might have contributed 100 times more than the other to current CO2 levels.	We do not agree that this is misleading but have taken the comment into account in revisions to provide a clearer rationale and context. The intent of this example was not at all to focus on contribution to past climate change, but the contribution of future emissions to future climate change - relative to the absence of those emissions. A focus on the mitigation of future climate change has to look at warming with, compared to without, future emissions - this is what GWP or GTP do, but GWP* (at least as applied in most of the literature to date and suggested by this and other review comments) does not.	Collins	William	University of Reading	United Kingdom (of Great Britain and Northern Ireland)
31941	23	1	24	20	It is helpful to have a specific discussion of GWP* because it has received quite a bit of attentionl since AR5, but it should be noted it is only one example (arguably the simplest -- but they all try to do the same thing) of a metric that captures the stock-flow properties of SLCPs. Others with similar behaviour would include forcing-equivalent emissions (Wigley, 1998; Jenkins et al, 2018), which is the most physically-based option, GTP_S (which is really the first variant of GWP* by another name, Shine et al., 2005), mixed metrics (Lauder et al., 2012), or CGTP (Collins et al., 2019). Well done for stressing GWP* isn't really a new metric, but a different usage of GWP100.	Thanks and the introduction of GWP* has been expanded to more fully present the range of flow/stock metrics that it is a representative of (focusing on CGTP which is given strong prominence in the WGI assessment).	Allen	Myles	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
31937	24	1	24	1	It should be noted that precisely the same problem applies to GWP100: countries can have the same current CO2-e emissions and very different historical contributions to warming to date. In fact, GWP* makes discussions of historical responsibility easier, because cumulative emissions to date calculated with GWP* reflect contributions to warming to date and current emissions under GWP* reflect contributions to the current warming rate (Allen et al, 2018). This point should be made in the revision.	Accepted with modifications; GWP100 is explicitly silent on the contribution from past emissions to current and future climate change, it focuses only on the contribution from each emission to future climate change, relative to this emission not ocurring. However, GWP* does not equate to historical responsibility, because (see comment 28519) historical emissions of SLCF contribute very little to future warming; hence cumulative emissions to date calculated with GWP* do not imply a historical responsibility for future warming.	Allen	Myles	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
14619	24	1	24	2	Suggested rephrasing to better indicate the specific strengths of GWP*: "However, this concern is related to the potential use of GWP* for policy rather than its ability to link cumulative CO2-equivalent emissions to future temperature outcomes."	Accepted	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
28523	24	10	24	10	"appear" - I don't think this is correct. Declining CH4 emissions ARE equivalent to negative CO2 emissions.	Accepted with modifications - have the equivalent effect on *changes in temperature* as negative CO2 emissions.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
14621	24	3	24	12	This discussion can be further developed into an assessment of these characteristics. For example, a statement indicating based on Schleussner et al (2019), Fuglestvedt et al (2018), and Tanaka and O'Neill (2019) that any switch away from GWP-100 for assessing mitigation under the Paris Agreeement would require a carefull assessment and reformulation of its Article 4 in order not to change the ambition or internal consistency of the agreement.	We have added a whole new section that discusses the issues that need to be considered if/when GHG metrics were to be changed in different contexts.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
27533	24	3	24	12	This argument seems to be discussing the physical aspects which are addressed more appropriately in WG 1, and is not needed here. Indeed a step-pulse metric will accurately imply constant temperatures for a net balance. If a decreasing temperature is required then a net negative balance would been needed - with the exact extent of the imbalance for the desired cooling given by the step-pulse metric. It seems bizarre to argue that because the GWP is an erroneous measure, and the error is in a beneficial direction it is somehow a preferable metric. I suggest all this discussion should be removed from the WG III report and passed to WG I.	Taken into account. We disagree that this is about physical aspects only, as Article 4 of the Paris Agreement is highly relevant to mitigation and hence addressed by both WGI and WGIII. However, we have revised the text to make clearer the factual situation. The comment by the reviewer seems to suggest what the Paris Agreement *ought* to have said (e.g. net negative emissions, using GWP*, if declining temperatures are required) - but our assessment has to deal with what the Paris Agreement actually says and what the science can tell us about what the outcome would be if the wording of the Paris Agreement is achieved but different metrics are applied. It is then for policymakers to decide if they wish to revise the Paris Agreement or are happy with the outcomes (whether accidental or deliberate during the initial negotiation of the Agreement).	Collins	William	University of Reading	United Kingdom (of Great Britain and Northern Ireland)
28521	24	3	24	12	This is almost impossible to follow. The GWP appears to achieve declining temperatures from constant emissions by accident rather than design. Declining temperatures, if that is truly the aim of Paris could be achieved by declining emissions as defined by GWP*. We shouldnt be slaves to the lack of a clear definition of what balance means in Paris.	Taken into account in revisions. The point remains that the Paris Agreement as it stands seeks net-zero GHG emissions during the second half of the 21st century, and that this would imply constant temperature if emissions are weighted based on GWP* and declining temperatures if they are weighted based on GWP100 - even if this is accidental. However, we have modified the text to make clearer that this is the situation.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)
28671	24	3	24	12	This is incorrect. GWP* would just make the choice to reduce temperatures an explicit part of the negotiations. There's nothing in the *metric* that would prevent a return to 1.5C. And the idea that reliance on a metric will drive action in this way, as the current text seems to imply, is absurd: if countries choose to reduce temperatures after they have peaked it will be because they either choose to continue mitigation or because it falls out of the technological/social/economic system at the time. It won't be because of an essentially arbitrary choice regarding metrics made on the fly circa 1990 which has never really pased master with climate scientists (however popular it is with science-bureaucrats).	Rejected; the reviewer discusses what might drive global action, whereas the text simply states what the temperature consequences would be if action consistent with the agreed text of the Paris Agreement took place. Yes it is correct that using GWP* would force a discussion on whether to reduce temperatures, but this would then require a change in the Paris Agreement text, whereas we focus on what the existing, agreed text provides for. However, we have revised the text based on other comments (e.g. 28521) that may address this comment indirectly.	Frame	Dave	University of Wellington	New Zealand
32157	24	3	24	12	For context, it's worth mentioning that use of any metric to interpret art 4 will give you a different temperature pathway. As he Paris Agreement has vague language surrounding what art. 4 means, there is no 'right answer' Wigley 2018 notes this inconsistency.	Accepted and incorporated in the revisions to this text.	Cain	Michelle	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
35563	24	3	24	12	There is no agreement on the interpretation of "balance of sources and sinks" nor any presumed way of determining this point. This is a piece of constructive ambiguity resulting from the negotiations. A definitive interpretation can only come from a consensus of the Members of the Agreement. This point might be worth including as it gives a necessary context context to the arguments reviewed here.	Accepted	Macey	Adrian	Victoria University of Wellington	New Zealand
37157	24	3	24	12	There are more issues with GWP* and Article 4 than the ones mentioned here. Specifically, it is possible to achieve Article 4 without net-zero CO2 emissions thereby failing to even halt global warming. Secondly, achieving net-zero after 2050 in Article 4 is inconsistent with achieving the temperature goal expressed in Article 2. It is a good example how great caution needs to be taken when applying novel metrics in an established policy context.	Noted; we base our assessment on the published literature rather than an independent evaluation of the different metrics. However, the generic point that introducing novel metrics into an existing agreement and targets poses problems is included explicitly in a new section that discusses issues around metric changes.	Schaeffer	Michiel	Climate Analytics	Netherlands
31929	24	7	24	12	There is nothing in the Paris Agreement to indicate that 1.5C was to be approached from above. The assumption that it will be overshot is scenario- and model-dependent, and so not relevant to a discussion of metrics. Likewise, it is not true that net zero emissions must be achieved before 2050 if evaluated with GWP*. In fact, elsewhere the chapter notes that temperature stabilisation occurs around 2055 in 1.5°C scenarios, which makes sense if we are now at 1.1C, warming at 0.2C per decade and decellerate steadily starting now (Leach et al, 2018). Since the paragraph earlier notes that constant temperatures are consistent with net zero emissions under GWP*, GWP* emissions must reach net zero at about the time temperatures peak. The result in Schleussner et al refers to a specific set of scenarios from IAMs in which mitigation efforts for different gases were determined using GWP100, so it is completely inconsistent to use them to criticise GWP*!	Taken into account. There is indeed nothing in the Paris Agreement that says that 1.5°C has to be approached from above, but that doesn't mean we should undertake our assessment in deliberate ignorance of current emission trends and near-term emission targets by countries, and the resulting likelihood that the 1.5°C limit will be exceeded. Evaluation of the AR6 emission scenario database shows that reaching net-zero GHG emissions if using GWP* is a robust feature of 1.5°C pathways. Most of the rapid CH4 abatement in those pathways occurs because of the rapid decarbonisation of energy supply and the presence of low-cost abatement options in other sectors, not because of GWP100. It is simply an example that net-zero GHG based on GWP* does not necessarily coincide with peak temperature. However, we have revised the text to make clearer that this is not a necessary but a potential feature. GWP* is only an approximation that does not recognise decadal-scale inertia in the climate system. The scenarios from the SR15 and AR6 database robustly show that if MAGICC is used to evaluate temperature, the time of net-zero GHG using GWP* does NOT coincide with peak temperatures. We have clarified this to avoid the sense that there is a physical inconsistency.	Allen	Myles	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
27535	24	9	24	12	This sentence doesn't seem to make sense. The necessary balance of sources and sinks to achieve 1.5deg is a physical calculation that can be determined using simple climate models such as MAGICC (as done in SR1.5). The GWP* (and other step-pulse metrics) can be used as a good approximation to using MAGICC, so there is no sense in which GWP* would require an earlier balance than a full calculation using MAGICC. The balance is determined by the physics, not the metric.	Taken into account; but GWP* is only an approximation that does not recognise decadal-scale inertia in the climate system. The scenarios from the SR15 and AR6 database robustly show that if MAGICC is used to evaluate temperature, the time of net-zero GHG using GWP* does NOT coincide with peak temperatures. We have clarified this to avoid the sense that there is a physical inconsistency.	Collins	William	University of Reading	United Kingdom (of Great Britain and Northern Ireland)
31931	24	13	24	13	Good. Including a contributing author who has actually worked on stock/flow metrics, such as Michelle Cain, might be a very good idea to keep this discussion balanced.	The author team already includes two co-authors of GWP* papers, we don't think that missing expertise is the reason why the reviewer disagrees with parts of this assessment.	Allen	Myles	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
28525	24	14	24	14	I think ths is a fair summary, even if I think that some of the "low agreement" arises from spurious objections to the use of mixed pulse/sustained metrics, which seem to mix unrelated issues. But I recognise that the IPCC authors can only assess what is in the literature.	Noted, thank you. The confidence level and wording has been reconsidered by the author team in light of additional literature.	Shine	Keith	University of Reading, UK	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
31933	24	14	24	14	Using "step-change" to refer to GWP* is not accurate: the variant in Cain et al (2019), which is the one the authors now consistently recommend (earlier variants are only useful for point-scoring),	Accepted	Allen	Myles	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
14623	24	14	24	20	The concluding statement should communicate the assessment of both the strengths and the weaknesses of the various metrics.	Taken into account as part of revisions to the conclusions section	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
14625	24	14	24	20	There is a mismatch in confidence assessment throughout this box. In some cases a very limited amount of studies (no more than 5) lead to "very high confidence" whereas in other cases the same "limited evidence" leads to no confidence statement at all. This imbalance should be evened out.	The uncertainty assessment has been updated as part of the revisions, and explanations added where their use might appear inconsistent. In the case of GWP*, there is a very robust case based on fundamental physics that this metric does a better job than GWP100 in representing temperature change associated with declining SLCF emissions. In this case, we consider that fewer specific studies are necessary to justify a high confidence in this conclusion.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
31939	24	17	24	20	This is prescriptive, because it depends on what is considered an "appropriate application". In the context of a long-term temperature goal, a more accurate indication of impact on global temperature might well be considered appropriate.	Taken into account as part of revisions; yes information about evolution of global temperature is a relevant piece of information, but not necessarily the most relevant piece. As clarified in the revised introduction to this box, some policy applications around allocation of resources towards mitigation efforts are concerned solely with the contribution of future emissions to future climate change, relative to the absence of those emissions, not the evolution of temperature relative to a specific reference point that would result from both historical and future emissions.	Allen	Myles	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
35561	24	17	24	20	This sentence is tendentious and introduces issues surrounding applicability of metrics that are best discussed under the substantive policy areas. A simple solution would be to add to the first sentence … " and to help inform policy " -	Taken into account as part of revisions; the question of what metric, when applied in which way, supports which policy applications is a core part of the discussion in this box. There are virtually no examples of GWP* being applied to a specific policy problem such as LCA, emissions trading schemes, carbon pricing etc. Revised text clarifies this.	Macey	Adrian	Victoria University of Wellington	New Zealand
4961	24	24	24	25	This statement about stability of regional shares doesn't match Figure 2.5 where there has been a big change in shares of developed countries and Asia since 2000.	Accepted. This is a very mixed-up statement that need to be cleaned up.	Stern	David	Australian National University	Australia
4963	24	27	24	29	For example, the UK has reduced CO2 emissions by about 25% from the peak in a fairly consistent way. Maybe this needs to be rephrased to make clearer that though some countries have had sustained emissions reductions they are not yet at the rate required by a 2C scenario? Are you sure no country is reducing rapidly enough? Figure 2.6 looks like some might be.	Accepted. We have clarified this statement and provide a proper benchmarking of historical emission reductions by countries vs requirements from global scenarios.	Stern	David	Australian National University	Australia
32187	24	27	24	29	Does it consider the report of Climate Action Tracker (2019) which suggets that NDCs of few countries are compatible with 2 degree C goal.	Rejected. This type of evidence is dealt with in chapter 4. Here we benchmark historical record against scenario evidence.	DUBE	LOKESH CHANDRA	NATCOM Cell, Ministry of Environment, Forest and Climate Change, Government of India	India
15935	24	30	24	30	developing pacific is typo should be capitalized	Accepted.	Takarina	Noverita	Universitas Indonesia	Indonesia
15937	24	30	24	30	Why are you providing only general Asia (also look at Figure 2.5 in page 26). It should be more specific by dividing Asia into sub regions like South East Asia which is this sub groups may be providing more interest facts.	Rejected. We use the AR6 regional classification. Note that two of the five regions involve Asia.	Takarina	Noverita	Universitas Indonesia	Indonesia

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
26169	24	32	24	33	Better to consider emissions from Africa and Middle East separtately. Current patterns and Future trends of production structure are different	Rejected. Regional classifications have a political aspect. Chapter 2 authors are not involved in developing the regional classification. We use what the TSU in liaison with the WG Buerau provides to us.	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
5183	24	41	24	42	There is a grammatical error in the sentence. It can be corrected as "Still, two countries (China, India) contributed more than 60% to the net increase in GHG emissions during 2010-2018.	Accepted	Alataş	Sedat	Aydın Adnan Menderes University	Turkey
30453	24	41	24	42	repeat of 'two countries'	Accepted	Cook	Lindsey	Quaker United Nations Office / Friends World Committee for Consultation (IPCC Observer)	Germany
34575	24	41	24	42	carefully check needed	Accepted	Meng	Jing	University College London	United Kingdom (of Great Britain and Northern Ireland)
38775	24	41	24	42	Re-word sentence because it is confusing with two verbs “contributed” and “was driven”.	Accepted and corrected	Reyes	Julian	Personal Capacity	United States of America
2901	24	42	24	42	As stated in footnote d: "Note that GHG emissions from international aviation and shipping as well as CO2 emissions from FOLU could not be attributed to individual countries or regions". Indeed, in accordance with IPCC Guidelines (e.g. Vol.1, Ch.8) emissions from fuel used on international ships and aircrafts should not be included in national totals. However, to ensure global completeness, these emissions should be reported separately and thus can be attributed to individual countries. As regards FOLU, its unclear to what specific source this statement is refering to? E.g. CO2 emissions from mineral soils can be attributed to individual countries. Consider to remove footnote d.	Accepted. We show those emissions separately in the subsequent figures.	Pyrozhenko	Yurii	IPCC TFI TSU	Japan
32181	24	42	24	42	Delete 'was driven by two countries'	Accepted and changed.	DUBE	LOKESH CHANDRA	NATCOM Cell, Ministry of Environment, Forest and Climate Change, Government of India	India
38361	24	42	24	42	The phrase "was driven by two countries" can be deleted.	Accepted and changed.	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
42679	24	41	25	2	Chhabra and Gohel (2017) reported an increasing trend of 2.15 ppm/year in the annual mean CO2 growth rate over India. The publication may be refered in context of India.	Noted	CHHABRA	ABHA	Space Applications Centre, Indian Space Research Organisation	India
24829	24	42	25	2	Delete "and ten countries … jointly contributed 85%."	Rejected. No rationale why that sentence should be deleted.	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
3153	24	24	27	20	Section 2.2.2 focuses on GHG emissions in the past couple of decades and some charts present changes in recent years. However, climate change does not occur due to GHG emissions in recent years or recent couple of decades only. Instead, climate change is caused by GHG emissions since pre-industrial times. To give the readers a historical perspective, discussions in the main text should be extended backward in time. Additional charts with a historical perspective should also be presented. Please consider incorporating some useful materials in the latest Global Carbon Budget 2019 (https://www.globalcarbonproject.org/carbonbudget/19/files/GCP_CarbonBudget_2019.pdf, page 87-88).	Rejected. Long-term trends are presented. Otherwise WGIII leadership encouraged to focus on recent changes as IPCC reports would otherwise continue to repeat themselves.	LEE	Sai Ming	Hong Kong Observatory	China
31943	24	23	28	27	It would be very helpful to distinguish, in all these figures, the contribution from long-lived pollutants CO2 and N2O, since this is the component that must unambiguously be brought to zero or below to halt warming.	Rejected. The box on emissions metrics explains the WGIII approach	Allen	Myles	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
1277	24	24		25	substantiate with literature	Noted	Anoruo	Chukwuma	University of Nigeria, Nsukka	Nigeria

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
10325	24	23			This section should lead with a clear exposition of what regional disaggregation is used in this repoprt and why, andf then systematically set regional findings in a global context (i.e. where specific regions or countries are called out, clarify their percentage contribution to totals, relevance of trends in those countries/regions, etc for global outcomes), not simply use the index because it's there.	Rejected. This should be done in one of the technical appendices. However, we write out the labels explicitly.	Reisinger	Andy	NZAGRC	New Zealand
10329	24	23			I'm missing a discussion of drivers of regional emissions here - it seems less relevant, and in the eyes of some potentially even misleading, to present trends without discussing drivers (whereas the next section on consumption based trends does discuss drivers extensively).	Rejected. Regional drivers are discussed in 2.4	Reisinger	Andy	NZAGRC	New Zealand
27537	24	23			This section should report emission trends separately for the gases as constant emissions of short-lived gases such as methane do not add to the cumulative carbon budget (see box 2.2).	Noted	Collins	William	University of Reading	United Kingdom (of Great Britain and Northern Ireland)
47649	24	24			"Regional contributions to global GHG emissions have remained surprisingly stable" - odd phrasing - contradicted in next paragraph	Accepted	Slade	raphael	Imperial College	United Kingdom (of Great Britain and Northern Ireland)
14369	24	30			Should be Developing Pacific	Accepted	Bradshaw	Michael	University of Warwick	United Kingdom (of Great Britain and Northern Ireland)
43915	24	35			Emission sectors should be mentionend along with the numbers indicating decline. E.g. How does the inital statement of stable GHG emissions match with recent publications, e.g. by IEA where GHG emissions of developed countries are decreasing slightly in the energy sector? Executive summary needs to be clearer on what are consumption-based emissions, later on trade-related emissions?	Rejected. We refer to total GHG emissions across all sectors. They are stable at about 15GtCO2eq.	and Elvira Poloczanska	Hans Poertner	Alfred-Wegener-Institut	Germany
47651	24	42			sentence doesn’t make sense	Accepted and changed	Slade	raphael	Imperial College	United Kingdom (of Great Britain and Northern Ireland)
5185	25	4	24	4	The sentence should be written as "developed countries"	Language here has been revised.	Alataş	Sedat	Aydın Adnan Menderes University	Turkey
38363	25	3	25	3	In what year were GHG emission levels 22 GtCO2eq in Asia in Developing Pacific?	Accepted and changed	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
38365	25	4	25	5	For what year are the per capita CO2 emissions values?	Accepted and changed	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
32183	25	7	25	8	The emission reduction is not sustained in these 18 countries as claimed. The emission reductions are fluctuating (rising and falling) as per fig 2.6. Though there is net reduction in emission over time, calling it sustained reduction may not be appropriate, particularly when few of these countries are showin increasing trend in most recent years as compared to previous year (e.g. Romania, France, Iceland, Spain, Bulgaria, The Netherlands, Italy, Portugal, Hungary, Belgium and Croatia.).	Noted. We changed the enitre section and expanded the analysis to all GHG emissions.	DUBE	LOKESH CHANDRA	NATCOM Cell, Ministry of Environment, Forest and Climate Change, Government of India	India
24831	25	8	25	9	Delete "This progress is partially … by renewable energy". Refer also to energy efficiency improvement	Noted	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
15939	25	9	25	9	You mention renewable energy…please mention what kinds of renewable energy?	Noted	Takarina	Noverita	Universitas Indonesia	Indonesia
38369	25	10	25	10	The Le Quéré et al. references are a mess at the end of this chapter and need to be cleaned up.	Noted	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
36441	25	7	25	12	I find that statement here a bit one sided: Another reason that need to be added is the fossil fuel based externalization of production to China and developing countries that should be added here. This among the reasons stated here are potentially the main reasons for the strong decrease in some countries or one could also say that the decrease in these countries actually drives the increase in China et al	Rejected. This is covered in Section 2.3. Here we talk about territorial emissions. Still, we tried to balance the text further.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
38367	25	7	25	12	The summary of this study as written here is not accurate. The findings are: "Results show that the largest contribution to emissions decreases in the peak-and-decline group for the 2005–2015 period was from decreases in the fossil share of final energy, accounting for a median (25th–75th percentile) of 47% (36%–73%) of the decrease in emissions (Fig. 2), and decreases in energy use, accounting for 36% (18%–56%)." In this study, energy use is defined as "changes in final energy, attributable to changes in the efficiency with which energy services are provided and consumed". They find that "decreases in energy use in the peak-and-decline group could be explained at least in part by the lower growth in GDP" but also that "Decreases in energy use were correlated with the number of energy efficiency policies" and "Decreases in the energy intensity of GDP (see Methods) were also correlated with policies on energy efficiency (r = –0.42) but were significant only at the 90% level (Table 2)." The actual conclusion (as opposed to what is said in the abstract) is: "These correlations provide indirect evidence that policies on energy efficiency may be playing an important role in driving emission reductions across countries, and that policies on renewable energy act to displace fossil fuel energy in the peak-and-decline group, but not elsewhere." I recommend using this last sentence to summarize this study, changing the text in Chapter 2 to read: "Policies on energy efficiency may be playing an important role in driving reductions in energy use and emissions reductions, although the reductions may be somewhat explained by lower growth in GDP."	Noted. We have re-vamped the entire analysis including broadening to all GHG emissions-	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
30455	25	1	26	1	p. 25 states that the Russian Federation is one of ten countries that has driven GHG emissions, and a figure in .26 show it as declining. Is this correct?	Noted. If you look at the figure you will see that emissions decreased in the long-term, but recently (2010-2018) it increased. We have now added text that explains the country emission decline figure better	Cook	Lindsey	Quaker United Nations Office / Friends World Committee for Consultation (IPCC Observer)	Germany
30457	26	1	26	1	really helpful and clear figures, thank you.	Thanks.	Cook	Lindsey	Quaker United Nations Office / Friends World Committee for Consultation (IPCC Observer)	Germany
12131	26	1	26	2	I like the figures and that it identifies specific countries. please keep.	Thanks.	Kvalevåg	Maria Malene	Norwegian Environment Agency	Norway
18423	26		26		Figure 2.5 © and (d)show the analysis in the period of 2010-2018. it is a very short period. The data from at least 1900 need to be involved to show a full picture to the reader.	Rejected. To focus on the period 1990-2018 was a decision by the WGIII Bureau. We further focus on 2010-2018, because this is the new data since AR5.	Shiyan	Chang	Tsinghua University	China
35019	26		26		The graphs on this page (a, b, c, and d) are misleading. These graphs need to be modified to reflect the role of countries in greenhouse gas emissions during the post-industrial revolution and rank countries accordingly.	Rejected. To focus on the period 1990-2018 was a decision by the WGIII Bureau. We further focus on 2010-2018, because this is the new data since AR5.	Ehsan	Taghavinejad	NIOC	Iran
38371	26	1	27	10	Regarding Figure 2.5, panel f, if you are going to present GHG emissions intensity using GDP values, you need to explain how the various currencies are converted to $, whether this is MER or PPP $, and note the $ year. If your values are just CO2, then this should be labeled CO2 emissions intensity (not GHG). If your values are just CO2, then it might be more interesting and informative to present emissions/unit of energy use as a measure of emissions intensity rather than GDP values.	Thanks, we will correct the CO2eq labels in the next iteration of this figure (they are all GHGs). Regarding GDP, we now note the use of constant international purchasing power parity (US $ 2011).	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
15941	26	1	30	1	Put the title of figure in the same page with the figure itself!. If separated it makes the reviewer / the reader hard to read and iunderstand. Otherwise, arrange the figure and its title together in same page in landscapa format.	Thanks, we aim to condense this figure further in the next iteration and use a single page.	Takarina	Noverita	Universitas Indonesia	Indonesia
10327	26	1			This is another potentially very useful figure, and for this reason it deserves a lot more work. I'm not convinced that the bar charts are the most meaningful way of conveying the relevant information - I would prefer an approach that shows individual countries relative to the regional trends (i.e. merging panels e/f with b). Also relevant would be any trends in emissions per capita at country level since single years can fluctuate quite a bit. I also wonder whether it is helpful to show individual countries in panels c and d -the focus on both percentage and absolute change is important, but it isn't clear why some countries are listed individually whereas others are listed as part of a group. Also is it possible to show that/how the rank of individual countries changes for the different metrics/panels?	Noted. We made the graph less busy by removing two panels. Otherwise, we had challenges fitting more information. But there are three additional figures that show country-level information explicitly or implicitly.	Reisinger	Andy	NZAGRC	New Zealand

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
14371	26	2			Figure 2.5 at top in key should be Developing Pacific—this is a general inconsistency in this chapter	Thanks, we have changed this as suggested.	Bradshaw	Michael	University of Warwick	United Kingdom (of Great Britain and Northern Ireland)
17445	26				in figure2.5d-why GHG emission growth in IRAN is same as US?	Noted. This is the recent change in emissions. US reduced emissions (mainly due to switching from coal to gas) and Iran increased emissions.	Sadegh	Zeyaeyan	Islamic Republic of Iran Meteorological Organization (IRIMO)	Iran
36439	27	1	27	1	Fig 2.5a is identical to fig 2.2a. Can they be merged or is it useful to keep them between subsections identical?	Please note these figures are not identical: 2.5a shows a breakdown of global emissions growth by region; figure 2.2a shows the breakdown of global emissions growth by greenhouse gas.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
9371	27				the beginning of the section like a list is too long and confusing. Bullet points after a brief intro should be framed here (ref. 2.7.1.2 Differences in household carbon footprints between and within countries 21 A number of factors socio -demographics, socio -economic status, infrastructure and access to public 22 services; the regulatory frame; availability, affordability and accessibility of more or less sustainable 23 choices on markets; individual values and preferences are affecting people's consumption patterns and 24 associated carbon emissions (Dietz et al. 2009).)	Apologies. The comment clearly does not refer to page 27. We could not identify the passage referred to and were unable to respond in this case.	PISELLO	ANNA LAURA	DEPARTMENT OF ENGINEERING - UNIVERSITY OF PERUGIA, ITALY	Italy
38373	28	11	28	12	Regarding this statement: "Consistent estimates for indirect CO2 emissions from final energy use are not available for this report at the moment." I strongly urge you to complete this work and include it in AR6. AR5 included an iconic figure showing both direct and indirect emissions that was highly regarded in AR5 and appeared not only in the WGIII full report, but also in the AR5 Synthesis Report (Fig. 1.7), the AR5 Summary for Policymakers (Fig. SPM.2), and the Technical Summary (Fig. TS.3). This report's inclusion of consumption-based emissions, while important, does not replace the full accounting of direct and indirect emissions that was covered in AR5. CBE is a *different* approach that is not as well established, as you state on page 30, lines 32-34 ("When calculating consumption-based emissions, several methods have been used. Different approaches using different system boundaries and different levels of sector and country detail may provide significantly different estimates, and may have particular advantages or disadvantages..."). CBE cannot be considered as a replacement for full accounting of territorial emissions or production based emissions. Even thought CBE is an important approach and should be further developed and pursued, governments around the world still only use territorial emissions for making domestic policy decisions and these decisions will be poorly informed if the end-use sector emissions do not include the indirect emissions attributed to end-use activities. I further note that Chapter 11 (Industry) has made this calculation and has included the direct and indirect CO2 emissions for the industry sector in their chapter. I have not checked to see if the buildings and transport sectors have also done this, but I recommend that they do.	Indirect emission data including a figures has been worked into the section.	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
30459	28	1	29	1	It could help non-specialist readers if you could spell out 'F-gas/ODP consumption	Figure has been removed.	Cook	Lindsey	Quaker United Nations Office / Friends World Committee for Consultation (IPCC Observer)	Germany
16201	28	1	30	7	For Section 2.2.3 Sectoral GHG Emissions Trends, consider adding military usage as a relevant sector. Estimates of uncertainty are incomplete without this sector included, even if accurate data are not available.	Rejected. We do not have the relevant information in our data. Moreover, sector boundaries have been agreed by the entire author team and could not be easily changed.	Helman	Daniel	College of Micronesia-FSM	Micronesia, Federated States of
17623	28	2			Make sure definitions are clear – eg. ("energy sector" as defined in Chapter 6 – mainly electricity and refining industries???)	Noted, There should be a technical appendix on this.	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
24241	28	3			Definition of acronyms should appear at their first appearance (e.g., AFOLU).	Accepted.	Zhifu	Mi	University College London	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
12653	28				Agriculture and LULUCF should be reported separately. Because all the reports on National GHG has been reported Agriculture and LULUCF emissions/removals separately.	Rejected. But there is an entire chapter on AFOLU, where this might be more realistic. Here our data does not allow for an easy distinction.	Özdemir	Eray	General directorate of Forestry	Turkey
15943	29	1	29	1	If we look at the IPCC 2014 in https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data, the sequence are electricity>afolu>industry>trans>building; how in this report it changed into energy>industry>AFOLU>trans>building. Why you don't use the same terminology? Is it the electricity as same as energy category?	Noted. I do not believe that the order is important. The system boundaries are broadly comparable.	Takarina	Noverita	Universitas Indonesia	Indonesia
26171	29		29		Energy systems (first part of the graph) in chap 6 includes also final consumption not only supply side. To avoid confusion with chapt 6change energy systems to energy.	Noted	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
34795	29		29		Do Not Cite, Quote or Distribute	Noted	Adojoh	Onema	Missouri University of Science and Technology, Rolla, USA	United States of America
34797	29		29		The do not cite, quote or distribute chart labels on page 29 is not as clear as the one on page 26. Author(s) should relabel neatly.	Noted	Adojoh	Onema	Missouri University of Science and Technology, Rolla, USA	United States of America
12655	29				Agriculture and LULUCF should be drawn separately. Because all the reports on National GHG has been reported Agriculture and LULUCF emissions/removals separately.	Rejected. But there is an entire chapter on AFOLU, where this might be more realistic. Here our data does not allow for an easy distinction.	Özdemir	Eray	General directorate of Forestry	Turkey
17171	30	2	30	2	Please check: AFOLU usually refers to "agriculture, forestry, and other land use", not "land use change". If you want to refer to land use change only, LUC would be the appropriate abbreviation.	Noted. We discussed forth and back on this. We now agreed to refer to AFOLU-CO2 emissions	Rock	Joachim	Thuenen-Institute of Forest Ecosystems	Germany
26827	30	18	30	22	It looks like parts of domestic value chains that have been outsourced to other countries do not contribute to the calculation of PBE or CBE. So can you really be sure that this measure helps assess the level of decoupling between economic productivity and GDP? Be carefu here, if this measure is not water-tight, countries will use it to disavow responsibility.	Reject. This is partly true. CBE does take into account outsourced parts of the supply chain versus PBE does not. That's why we provide both types of dxecoupling measures.	Verchot	Louis	International Center for Tropical Agriculture	Colombia
46925	30	10	30	29	The chapter distinguishes territorial from consumption-based accounting of emissions. It leaves out the third possibility of the extraction-based principle (even more appropriately coined "production-based", but that is used differently in this chapter; see my comment 4). The extraction-based prinsiple assigns all emissions - from extraction, through refining, processing and transportation to consumption and scrapping - to the sector of origin. Jurisdictions where fossil fuels are extracted, but also where other productions like cement, metals and agriculture are taking place, will then be assigned the emissions from the whole value chain. See Steininger et al (2015) that is already in the reference list (or K W Steininger and T Schinko (2016) "Environmental Policy in an Open Economy: Refocusing Climate Policy to Address International Trade Spillovers", in Bednar-Friedl, B. and J. Kleinert (eds.): "Dynamic Approaches to Global Economic Challenges, Springer International Publishing Switzerland, DOI 10.1007/978-3-319-23324-6_11.) In addition, these two references discuss a fourth alternative: Income-based, that you could consider to mention.	Accepted and Added some discussions on the emission accounting scopes.	Fæhn	Taran	rerserach institute	Norway
17353	30	18	30	29	country's historic role and responsibility in greenhouse gas emissions should not be ignored. It is suggested that in addition to parameters PBE and CBE, a parameter named HBE(historical based emissions) to be considered in order to account for historical emissions of countries since industrialization so far.	Accept. We add a few sentences about historical cumulative emissions.	Sadegh	Zeyaeyan	Islamic Republic of Iran Meteorological Organization (IRIMO)	Iran
42641	30	30	30	30	Figure 2.8 is not self containing, territorial emissions is little different from PBE (except for EIT), some interpreting sentences in the main text are necessary	Accepted. We have revised the text above as well as this figure to make them consistent.	Eyckmans	Johan	KU Leuven	Belgium
26825	30	31	30	31	The figure caption needs more detail.	Accepted and added.	Verchot	Louis	International Center for Tropical Agriculture	Colombia
30461	30	1	37	30	Very helpful chapter, but trying to keep perspective on per capita consumption in addition to rising/lowering rates, as to compare USA with India, as with the chart on 33, is confusing - may need real clarity on overall consumption on an annual basis of a person - hard to imagine India per capita is higher than USA, but the reader could understand it this way.	Accepted. The figure has been revised.	Cook	Lindsey	Quaker United Nations Office / Friends World Committee for Consultation (IPCC Observer)	Germany

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
47661	30	9	47	16	Section 2.3 - consider restructuring, this section isn hard to follow, lots of data and detail but not clear what insights from the section should be included in the SPM	Accepted. This chapter has been restructured. We added discussions on CBE of cities (section 2.3.2); moved the text about trade conflict to chapter 2.4; moved the text about drivers to chapter 2.4; previous sections 2.3.4 (global supply chains and emissions) has been integrated into section 2.3.3 (emissions embodied in trade) and section 2.3.4 (geographical shifts in emission embodied in trade). We re-calculated the CBE and decoupling extent of countries with updated IEA and EDGAR emission data. We will present more data and details in this section.	Slade	raphael	Imperial College	United Kingdom (of Great Britain and Northern Ireland)
14231	30	9	47	19	It should be pointed out that studies of consumption based and production based emissions rarely consider emissions from land-use and agriculture (Wu, Zhu and Zhu which you use for the decoupling for example does not account for AFOLU emissions). Adding these emissions to the emission accounting would increase the consumption based and production based emissions estimates. That is why the finding that some developed countries have achieved a decoupling of GDP and consumption based emissions is a quite inconclusive, since significant imports of imported agricultural produce originates from unsustainable agricultural practices (e.g., forest clear-cutting,).See Pendril et al., 2019: https://doi.org/10.1016/j.gloenvcha.2019.03.002	Accepted. This should be discussed in the production section.	Slameršak	Aljoša	The Institute of Environmental Science and Technology (ICTA-UAB)	Spain
14627	30		47		It would be great if this section could also assess how consumption-based GHG emissions vary across income groups (globally) - if any evidence and data is available to this end.	Rejected. We have a figure showing this in section 2.6.	Rogelj	Joeri	Imperial College London	United Kingdom (of Great Britain and Northern Ireland)
22383	30		60		For these parts, it would be much better if some cases or specific examples could be cited to support the narratives on top of the general descriptions, For example, what has happened to developing countries and developed countries respectively, what does it look like in some typical country with both good performance and mediocre performance, in relation to the territorial and consumption-based GHG emissions, economic and socio-demographic drivers and their trends, and sectoral emission drivers as narrated in the texts.	We added a few sentences about the drivers of decoupling.	Zhao	Xiusheng	Tsinghua University	China
45933	30	9			Section 2.3: Additional references that could possibly be relevant wrt. decoupling: Hickel, Jason, et Giorgos Kallis. « Is Green Growth Possible? » New Political Economy, 17 avril 2019, 1-18. https://doi.org/10/gfzrxb. Kemp-Benedict, Eric. « Dematerialization, Decoupling, and Productivity Change ». Ecological Economics 150 (2018): 204-16. https://doi.org/10/gfbr69. Ward, James D., Paul C. Sutton, Adrian D. Werner, Robert Costanza, Steve H. Mohr, et Craig T. Simmons. « Is Decoupling GDP Growth from Environmental Impact Possible? » Édité par Daniel E. Naya. PLOS ONE 11, nº 10 (14 octobre 2016): e0164733. https://doi.org/10/gfztqx.	Accepted and discussed.	Marbaix	Philippe	UCLouvain, Belgium	Belgium
18859	31	12	31	33	Karakaya et al. (2019) argues the relevance of Production based emission accounting and consumption based emissions accounting system on similar issues as well as lekages, decoupling etc. Please see Karakaya, E., Yılmaz, B., & Alataş, S. (2019). How production-based and consumption-based emissions accounting systems change climate policy analysis: the case of CO 2 convergence. Environmental Science and Pollution Research, 26(16), 16682-16694.	Accepted text	Karakaya	Etem	Independent researcher, former Profesor,fired with the decree of law since 2016	Turkey
34577	31	34	31	34	CBE	Taken into account	Meng	Jing	University College London	United Kingdom (of Great Britain and Northern Ireland)
6917	31	34	31	36	global MRIO methodology with country and sector-specific emission intensities (and thus CBA) accounts for different emission intensities across countries	Taken into Account	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
17355	31	34	31	36	HBE (expressed in previous comment) can better explain the responsibility of countries in greenhouse emissions and global warming.	Taken into account	Sadegh	Zeyaeyan	Islamic Republic of Iran Meteorological Organization (IRIMO)	Iran
4965	31	40	31	42	Global CBE must equal global PBE, so you can delete these lines.	Accepted and revised.	Stern	David	Australian National University	Australia

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
34579	31	40	31	43	CBE is from consuption perspective, the global CBE is dviven by the onsumption in developed countries, not the emissions in developed countries. "in developed countries" is kind of misleading as it indicates the emissions are physically emitted in developed countries, though it is true in 1990, but not consistent herr to highlight CBE	Accepted. We have revised the text.	Meng	Jing	University College London	United Kingdom (of Great Britain and Northern Ireland)
17625	31	39	32	11	Make sure definitions are clear – eg. (as defined in Chapter 6 – mainly electricity and refining industries???)	Accepted and revised.	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
6913	31	4			Fernández-Amador et al. (2016; Ecological Economics; "Carbon dioxide emissions and international trade at the turn of the millennium"; http://dx.doi.org/10.1016/j.ecolecon.2016.01.005) and Fernández-Amador et al. (2020; Ecological Economics; "The methane footprint of nations: Stylized facts from a global panel dataset";https://doi.org/10.1016/j.ecolecon.2019.106528) also use global MRIO methodology to calculate emission footprints of CO2 and CH4 respectively.	this part is deleted, not applied.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
6915	31	27			border tax adjustment, or border carbon adjustment, is more commonly used than border trade adjustment	Accepted text	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
4145	31	36			Before ending the Box 2.3, it is recommended to add a paragraph on the necessity of shared responsibility allocation approaches among the producers and consumers of the embodied emissions: "Also, some researchers has proposed that there is an essential need for the development and application of shared responsibility allocation approaches among the producers and consumers of upstream and downstream emissions. The sharing of the burden of embodied emission among the emitters and consumers is critical in the design of an effective integrated global climate action. An effective approach motivates both the producers toward greener production and the consumers toward less and greener consumption, simulataniously. In addition to technology adjusted sharing approaches (Kander, et al, 2015), other proposed allocation techniques are based on the value added generation of the traded stream for the importer and exporter country (Feng, 2003, Rodrigues, Domingos, et al. 2006, Lenzen, Murray et al. 2007, Rodrigues and Domingos 2008, Zhou 2009, Hoeltl and Brandtweiner 2011, Marques, Rodrigues, et al. 2012, Berzosa, Barandica, et al. 2014, Csutora and Vetőné mózner 2014,) as well as their cumulative effects on resource depletion (Bastianoni, et al. 2004, Khajehpour, et al. 2019)." Complete addresses of the references are provided in cell I-16.	Accepted text	Khajehpour	Hossein	Energy Engineering Department, Sharif University of Technology	Iran
4147	31	36			http://dx.doi.org/10.1016/j.ecolecon.2006.05.018 , https://doi.org/10.1016/j.ecolecon.2007.12.010 , http://dx.doi.org/10.1038/nclimate2555 , http://dx.doi.org/10.1016/j.ecolecon.2006.05.018 , https://doi.org/10.1016/S0921-8009(03)00104-6 , https://doi.org/10.3390/su9122220 , https://doi.org/10.1016/j.jclepro.2017.08.013 , https://doi.org/10.1002/ieam.1489 , https://doi.org/10.1007/978-3-319-89590-1_17	Accepted text	Khajehpour	Hossein	Energy Engineering Department, Sharif University of Technology	Iran
17437	31	36			Before ending the Box 2.3, it is recommended to add a paragraph on the necessity of shared responsibility allocation approaches among the producers and consumers of the embodied emissions: "Also, some researchers has proposed that there is an essential need for the development and application of shared responsibility allocation approaches among the producers and consumers of upstream and downstream emissions. The sharing of the burden of embodied emission among the emitters and consumers is critical in the design of an effective integrated global climate action. An effective approach motivates both the producers toward greener production and the consumers toward less and greener consumption, simulataniously. In addition to technology adjusted sharing approaches (Kander, et al, 2015), other proposed allocation techniques are based on the value added generation of the traded stream for the importer and exporter country (Feng, 2003, Rodrigues, Domingos, et al. 2006, Lenzen, Murray et al. 2007, Rodrigues and Domingos 2008, Zhou 2009, Hoeltl and Brandtweiner 2011, Marques, Rodrigues, et al. 2012, Berzosa, Barandica, et al. 2014, Csutora and Vetőné mózner 2014,) as well as their cumulative effects on resource depletion (Bastianoni, et al. 2004, Khajehpour, et al. 2019)." Complete addresses of the references are provided in cell I-16.	Accepted text	Sadegh	Zeyaeyan	Islamic Republic of Iran Meteorological Organization (IRIMO)	Iran

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
17439	31	36			http://dx.doi.org/10.1016/j.ecolecon.2006.05.018 , https://doi.org/10.1016/j.ecolecon.2007.12.010 , http://dx.doi.org/10.1038/nclimate2555 , http://dx.doi.org/10.1016/j.ecolecon.2006.05.018 , https://doi.org/10.1016/S0921-8009(03)00104-6 , https://doi.org/10.3390/su9122220 , https://doi.org/10.1016/j.jclepro.2017.08.013 , https://doi.org/10.1002/ieam.1489 , https://doi.org/10.1007/978-3-319-89590-1_17	Accepted text	Sadegh	Zeyaeyan	Islamic Republic of Iran Meteorological Organization (IRIMO)	Iran
17447	32	5	32	5	refrence???	Rejected. This is what we found, not from literature.	Sadegh	Zeyaeyan	Islamic Republic of Iran Meteorological Organization (IRIMO)	Iran
24833	32	10	32	10	Add "per" before the word "capita"	Accepted and revised.	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
6919	32	8			global total in terms of emissions or global total in terms of GDP?	In terms of global emissions. We have revised the text.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
26829	33	2	33	2	Because per capita changes are presented, it would also be nice to see absolute per capita CBE, so a figure like panel A, but in units per capita.	Accepted= and revised.	Verchot	Louis	International Center for Tropical Agriculture	Colombia
18427	33		33		It is better to start from the year of 1900.	Rejected. Data not available and not all that relevant for most recent trends.	Shiyan	Chang	Tsinghua University	China
18429	33		33		To avoide some political views, it is better to replace the name of the country with the name of region.	Rejected. It is better to show the differences between countries otherwise important information is lost in the aggregate. [but we will follow official IPCC guidelines on how to present country results]	Shiyan	Chang	Tsinghua University	China
24835	33		33		Figure 2.9 - lower part is not "by region" is "by country"	Accepted= and revised.	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
34581	33		33		it is better to present the results of ten regions	Rejected. It is more informative to show the differences for all countries rather than singling out a subset.	Meng	Jing	University College London	United Kingdom (of Great Britain and Northern Ireland)
45905	33	5	34	6	The first paragraph provides a common definition of absolute and relative decoupling (until p34 line 3). But the purpose of the decoupling index is unclear : it does not seem to be used in the following figure. It is odd to state state that "According to Wu et al. a decoupling index ..." : given the formulation that you provide here (which is not written in the same way as in Wu et al but is algebraically identical). All this is just evident, nobody needs Wu et al. to find out that, for example, absolute decoupling - defined as you just did in the previous paragraph - implies DI > 1 (as it is defined by delta_CO2 > 0). So those values are obvious and you are not making use of them : the sentence "According to Wu et al." does not seem justified nor useful. For clarity, I suggest merging those paragraphs, removing what is not needed.	Accepted= and revised.	Marbaix	Philippe	UCLouvain, Belgium	Belgium
45907	33	5	34	6	The name "decoupling" is used at least since 1990; I suggest looking at more references. For example, an early reference is Greenhalgh, Geoffrey. « Energy Conservation Policies » https://doi.org/10/b2f727, and for a definition and illustration of absolute vs relative decoupling, see EEA 1999, Environment in the European Union at the Turn of the Century, https://www.eea.europa.eu/publications/92-9157-202-0-sum/eu_98_uk.pdf	Accepted. But we will not provide a review as this is not the purpose of this section.	Marbaix	Philippe	UCLouvain, Belgium	Belgium
4967	33	5	34	8	There is a difference here between "correlation" and "causality". Yes in some countries emissions have fallen despite the economy growing but that doesn't mean that an exogenous increase in GDP would reduce emissions. It likely would increase emissions. It's other factors driving the decarbonization. This distinction is discussed in detail in several of my papers on the EKC including: Stern D. I., R. Gerlagh, and P. J. Burke (2017) Modeling the emissions-income relationship using long-run growth rates, Environment and Development Economics 22(6), 699-724., which was based on our work on the AR5 trends and drivers of emissions chapter. This is discussed better in Section 2.4 maybe there should a cross-reference between these two discussions of decoupling.	Accepted.We checked if the language implies any causality. That was not our intention. The discussion of this should indeed happen in section 2.4 on drivers .	Stern	David	Australian National University	Australia
10331	33	1			It would be good to ensure that this figure can be compared directly with Figure 2.5 showing production emissions. Also it is not clear by what logic some countries are included in this figure but not others.	Accepted and revised.	Reisinger	Andy	NZAGRC	New Zealand

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
6921	33	3			global total in terms of emissions or global total in terms of GDP?	Accepted and revised.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
47653	33	3			Figure 2.9 - is this an original figure? In which case need to give brief intro to EXIOBASE Is 2016 the most recent data?	Accepted. This figure is a original figure.	Slade	raphael	Imperial College	United Kingdom (of Great Britain and Northern Ireland)
24243	33	7			production-	Accepted and revised.	Zhifu	Mi	University College London	United Kingdom (of Great Britain and Northern Ireland)
32189	34	4	34	4	Footnote e: change 'Indexes' to 'Index'	Accepted and revised.	DUBE	LOKESH CHANDRA	NATCOM Cell, Ministry of Environment, Forest and Climate Change, Government of India	India
17173	34	9	34	12	Please consider renaming the Y-axes (avoid "/"). The graphs are hard to understand. They apparently show PBE and GDP growth, but the use of "/" implies that a ratio of "PBE divided by GDP" is shown. The same applies to the lower panel (CBE / GDP).	Accepted and revised.	Rock	Joachim	Thuenen-Institute of Forest Ecosystems	Germany
17175	34	9	34	12	Figure 2.10: Please use the same range for the axes in all panels to facilitate comparisons.	Accepted and revised.	Rock	Joachim	Thuenen-Institute of Forest Ecosystems	Germany
24837	34		34		Figure 2.10 states in the title the period 1990-2015, whereas the data in the graphs are for the period 1995-2016	Accepted and revised.	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
42643	34		34		footnote e: ugly formula, please simplify and clean up	Accepted and revised.	Eyckmans	Johan	KU Leuven	Belgium
6923	34	4	35	28	This discussion can be much more summarized and the important parts should be highlighted	Accepted and revised.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
17401	34	1		12	Why is it written that we have absolute decoupling while the trend of changes of two graphs are similar that indicates the correlation between them.	Rejected. The rates of growth are different in the two figures (relative decoupling and coupling)	Sadegh	Zeyaeyan	Islamic Republic of Iran Meteorological Organization (IRIMO)	Iran
10333	34	9			The figure shows that the categorisation into different decoupling categories, despite its clear definition, is highly ambiguous. To start with, it's not clear why PBE middle panel is called relatively decoupling, given that in this panel emissions have grown more than GDP? Also the trends in the CBE relatively decoupling and not decoupling panels are essentially similar (give or take a bit of noise) but are referred to as two fundamentally different categories. I'm also not clear why the CBE absolute decoupling panel is called that, because (given the rising CO2 CBE trend I don't see how this panel can have a decoupling index greater than 1!?) The authors need to ASSESS whether the decoupling index by Wo et al actually provides a useful framework for categorising country level outcomes and trends.	Accepted. The classification is based on Tapio decoupling index, and it capture the relative relationship of changes in CO2 emissions and GDP, rather than the absolute changes in emissions. We added some explaination.	Reisinger	Andy	NZAGRC	New Zealand
45911	35	3	35	4	Please consider adding the magnitude of the change in emissions for each group, over the considered time period (for PBE and CBE). That would help judging the real impact of each of those changes.	Accepted. The changes are added.	Marbaix	Philippe	UCLouvain, Belgium	Belgium
45913	35	3	35	4	Nice table, but some information is missing: you indicate that the data in the table is for 2016, but what is the time period over which the decoupling is evaluated?	Accept. The information has been added.	Marbaix	Philippe	UCLouvain, Belgium	Belgium
18433	35	5	35	5	I'd like express my concen about the expression of rich countires or poor countries. It is better not to use these words.	Accepted. We changed the country classfication.	Shiyan	Chang	Tsinghua University	China
4969	35	8	35	9	I would argue that little of it was from outsourcing pollution but mostly from changes in the energy mix etc. See Jiborn et al. (2015) Nature Climate Change for example, or Burke, Paul J. "Climbing the electricity ladder generates carbon Kuznets curve downturns." Australian Journal of Agricultural and Resource Economics 56, no. 2 (2012): 260-279.	Accepted.	Stern	David	Australian National University	Australia
32297	35	9	35	13	A similiar finding has also been reported by Jiborn et al (2020). This study used a recent version of WIOD database. This adds to the overall confidence (i.e three studies using different databases report similiar findings) of this trend. Jiborn, M., Kulionis, V., & Kander, A. (2020). Consumption versus Technology: Drivers of Global Carbon Emissions 2000–2014. Energies, 13(2), 339.	Accepted.	Kulionis	Viktoras	ETH Zürich, Ecological Systems Design	Switzerland

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
35851	35	9	35	13	The consumption emissions of the European Union (EU-28) rose by 88 million tonnes between 1990 and 2005, but by 2012 they dropped significantly by the order of 619 million tonnes from 2005. Yet, the transfers were net negative in all the years under study. This could be due to the fact that the EU was expanded in 2004 and 2007 to include 11 EIT states. Consumption emissions of the EIT Parties dropped by 30.19 per cent while those of EIT countries within the EU dropped by 23.62 per cent (https://www.epw.in/journal/2018/43/special-articles/estimating-greenhouse-gas-emissions.html)	Accepted.	Gupta	Himangana	Institute for the Advanced Study of Sustainability, United Nations University, Tokyo	Japan
45917	35	18	35	19	"In addition to the absolute decoupling of developed countries": this wording may suggest that all "developed" countries have declining emissions. Unless this is the case, could you consider a clearer wording, that would reflect the information in the previous paragraphs, - e.g. "most developed countries", or something more precise in term of countries or group?	Accepted and revised.	Marbaix	Philippe	UCLouvain, Belgium	Belgium
5187	35	19	35	19	The sentence should be corrected as "as a group".	Accepted and revised.	Alataş	Sedat	Aydın Adnan Menderes University	Turkey
45915	35	21	35	23	This sentence is not fully clear : do you mean "emissions may have increased faster again" ? Without the word "faster" it may be read as "emission weren't increasing anymore and started to increase again", which would not be consistent with "a short term decoupling" (or it would be absolute decoupling, but as I understand the paragraph, it is not what is meant?).	Accepted and revised.	Marbaix	Philippe	UCLouvain, Belgium	Belgium
18861	35	24	35	28	More references are needed for fast developing countries. The following reference for instance found no decoupling between CO2 emissions and economic growth for Turkey over the period of 1990 to 2016. Please see Karakaya, E., Bostan, A., & Özçağ, M. (2019). Decomposition and decoupling analysis of energy-related carbon emissions in Turkey. Environmental Science and Pollution Research, 26(31), 32080-32091.	Accepted. But we didn't disucss too many papers due to page limit.	Karakaya	Etem	Independent researcher, former Profesor,fired with the decree of law since 2016	Turkey
45919	35	24	35	28	What do you mean by "the large majority of countries" ? Countries by number ? Only fast-growing ones? Please clarify and link your explanation to the results in table 2.1	Accepted and revised.	Marbaix	Philippe	UCLouvain, Belgium	Belgium
42645	35	30	35	30	I miss a clear definition of EET, what is the relation between EET, PBA en CPE? Please provide more info in tekst	Accepted and revised.	Eyckmans	Johan	KU Leuven	Belgium
6927	35	30	35	33	Regional detail (by income group) on emissions embodied in imports and exports should be added before coming to the country-details on page 36. Such income-group breakdown of emissions embodied in imports and exports is provided e.g. in Fernández-Amador et al. (2016; Ecological Economics; "Carbon dioxide emissions and international trade at the turn of the millennium"; http://dx.doi.org/10.1016/j.ecolecon.2016.01.005) for CO2 and Fernández-Amador et al. (2020; Ecological Economics; "The methane footprint of nations: Stylized facts from a global panel dataset"; https://doi.org/10.1016/j.ecolecon.2019.106528) for CH4	not applied. We didn't use income group anymore.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
6933	35	29	38	8	Throughout the section it should be made clear whether imports and exports refer to net imports and net exports as seems to be the case in various occurrences (e.g. Line 25, line 26)	Accepted and revised.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
44967	35	29	38	8	It is suggested to include reference to the cases of coal and other fossil-based electricity imports from non-EU/EEA countries are seen all over the European borders: from the Baltic States, Poland and Bulgaria to Croatia, Greece and Spain. In 2019, 33 TWh of electricity worth €1.6bn was imported into the EU ETS region, having been generated in an effective carbon price haven. Countries in the EU ETS collectively imported 26MtCO2 (20MtCO2 net), equivalent to the annual emissions of the Italian coal fleet. Especially striking is the case of Spain and Morocco, while Spain phases out coal -between 2018 and 2019 domestic coal generation was reduced by by 25TWh- in Morocco new coal plants are built and end up exporting their production to Spain -between 2018 and 2019 net exports from Morocco to Spain increased by 4TWh-.	Rejected. The emissions related to imported electricity are scope 2 emissions. We are discussing scope 3 or consumption-based emissions in this chapter.	Pina	Jorge	ENEL	Spain
36449	35	29	40	11	I find this section very descriptive mainly presenting summaries of other findings with little conclusions or interpretation drawing from the results. Would be great to add final paragraph embedding it better by answering why, what does it mean for the global environmental perspective, and eventually what does it mean and influence other sectors and places elsewhere	Accpeted and revised.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
18411	35	1	40		The title of the chapter is emission trends and drivers, but too much time has been spent on international trade. Thegeographic shift of trade is not the key driver of emission reduciton.	Accept. This chapter aims to describe the trends of CBE in countries. International trades and global supply chains is the major reason that cause the gap between countries' PBE and CBE. Thus, we also discuss the trade embodied emissions in this chapter as well. We have added "emissions embodied in trade" in the title of the chapter. We also re-structured the sections on trade and emissions, shorten the part of "geographic shit of trade".	Shiyan	Chang	Tsinghua University	China
18431	35		40		There are too many duplications in section 2.3.2, 2.3.3 and 2.3.4 . It is suggested to compress these section into one section.	Accpeted. We have re-structured the text.	Shiyan	Chang	Tsinghua University	China
26175	35	30	41	26	In the emissons (EEI and EEE), are fossil fuels trade (coal, oil, natural gas) captured?	Yes. EEI and EEE refers to emission embodied in all trade stuff. We have made a definition of the items.	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
6929	35	2			A comparaison of decoupling between PBE and CBE would have been interesting. Research has shown that the income-elasticity of PBE is smaller than the income-elasticity of CBE (e.g. Aichele and Felbermayr, 2012, "Kyoto and the carbon footprint of nations", doi:10.1016/j.jeem.2011.10.005, and Fernández-Amador et al., 2017; Ecological Economics; "Carbon Dioxide Emissions and Economic Growth: An Assessment Based on Production and Consumption Emission Inventories", http://dx.doi.org/10.1016/j.ecolecon.2017.01.004, for CO2, and Fernández-Amador et al., 2019; Economics Letters; "Empirical estimates of the methane–income elasticity"; https://doi.org/10.1016/j.econlet.2018.07.012, for CH4.)	Reject. Our section focuses on CBE; thus we group the countries according to their decoupling extent of CBE and GDP. Please refer to section 2.2 for information about PBE.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
47655	35	5			is it possible to list countries in each category explicity	We use IPCC guidence for the country groups.	Slade	raphael	Imperial College	United Kingdom (of Great Britain and Northern Ireland)
17627	35	11			This paper (Wood et al. 2019c) also has a point of central importance to the debate, which is that for some sources (notably, mining and agriculture) embodied emissions are almost inevitable – Europe doesn't have the mineral or agricultural resources to generate these domestically.	Accepted. The argument is more subtle as the EU may have the resources but does not want to extract or produce those commodities due to other reasons. This might be a case of outsourcing due to stringent regulations or price differentials.	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
10335	35	29			This section feels repetitive, or somewhat disjointed, given that emissions embodied in trade are at the heartt of what was discussed in the preceding sections/discussion on CBE vs PBE?	We have restructured this sections and discussed PBE and CBE somewhere when properly.	Reisinger	Andy	NZAGRC	New Zealand
6925	35	31			"for GHGs" means GHGs other than CO2? Clarify	yes. Clarified.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
45909	36	6	36	9	It seems surprising to describe the emission transfer between OECD and non-OECD countries as "South-North": the main transfer is not between North and South. If you rename it as "developing - developed", it would be consistent with Wood et al 2009, but even that could be questioning : is the OECD - non-OECD division providing a complete view of how emission change and are transferred between roughly homogenous groups of countries? AR5 WGIII had figure 5.14, which divided countries in 5 groups. Could you explore whether a division in more than two groups wouldn't provide a more comprehensive view on what is happening and whether OECD / non-OECD is actually an optimal grouping wrt understanding emissions changes and transfers (the underlying papers provide data for all countries and some illustrations) ?	Rejected. We cannot change the names as this part is based on the grouping used in the literature and not our own calculations.	Marbaix	Philippe	UCLouvain, Belgium	Belgium
12133	36	11	36	13	We appreciate this paragraph about trade agreements/restrictions and associated emissions, please retain. Please consider to include such clear message in the related paragraph in the executive summary (e.g. Page 5 line 1-5).	not applied.	Kvalevåg	Maria Malene	Norwegian Environment Agency	Norway
18389	36	15	36	15	SINO-US or SINO-China?	not applied.	Shiyan	Chang	Tsinghua University	China
24269	36	15	36	15	Sino-China is wrong. Should be Sino-US	not applied.	Zhifu	Mi	University College London	United Kingdom (of Great Britain and Northern Ireland)
18391	36	15	36	16	Two index, GDP and CO2, are mentioned, but only one data value range are provided.	Accepted and revised.	Shiyan	Chang	Tsinghua University	China
24839	36	11	36	19	Consider the latest developments on trade disputes	not applied.	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria

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32299	36	20	36	22	Consider specifiying that it is in absolute terms. In relative terms smaller economies tend to have higher emissions embodied in trade i.e. share of emissions embodied in exports (or imports) as a share of total production (or consumption) emissions are higher for smaller economies.	Accepted.	Kulionis	Viktoras	ETH Zürich, Ecological Systems Design	Switzerland
18393	36	21	36	22	the format of references needs to be modified.	Accepted and revised.	Shiyan	Chang	Tsinghua University	China
5189	36	23	36	23	The sentence should be corrected as "as also for Brazil"	Accepted and revised.	Alataş	Sedat	Aydın Adnan Menderes University	Turkey
32301	36	29	36	33	Consider citing Xu and Dietzenbacher (2014) as it was one of the first attempts to explain the growth of emissions embodied in trade (EET)	Accepted and revised.	Kulionis	Viktoras	ETH Zürich, Ecological Systems Design	Switzerland
22403	36	15			"The Sino-China trade conflict that started in 2018" Sino-US ?	not applied.	LYU (Former family name LU)	ZHENG	Shanghai Advanced Research Institute, Chinese Academy of Sciences	China
6931	36	16			do the percentages in parentheses refer to GDP or CO2?	Accepted and revised.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
10337	36	29			This section needs to avoid a connotation that emissions embodied in trade are necessarily a problem, as it depends entirely on the counterfactual. If emissions embodied in trade arise because countries source their goods from wherever those goods can be produced at the lowest emissios intensity, then trade emissions are a sign of mitigation success. Obviously, if countries consume more because of trade, then trade emissions are bad. The section needs to offer a clear and value-neutral framework through which to understand the role and relevance of trade embodied emissions, and then assess those emissions and trends relative to that framework. At present I find the approach confusing and open to implicit value judgements that may or may not be borne out by the actual data. Also, consider the placement of this section relative to the earlier one about CBE vs PBE.	Accepted. This discussion of counterfactuals will be discussed in 2.4 and the more descriptive trade section shortened here.	Reisinger	Andy	NZAGRC	New Zealand
42647	37	7	37	7	Figure 2.12: EEI not defined (Emissions Embodied in Imports?)	Accepted and revised.	Eyckmans	Johan	KU Leuven	Belgium
18395	37	15	37	17	The logic is difficult to understand. The carbon intensity is product or sector based. If a country imports the same products, the carbon intensity is almost same no matter where they are produced. But if a country imports very different products, the carbon intensity will be quite different.	Rejected. Countries have different production/energy use technologies, so the carbon intensity in different countries are different.	Shiyan	Chang	Tsinghua University	China
36443	37	1	37	37	Here and throughout this subchapter: correct citation style (all are given in separate parentheses)	Accepted and revised.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
18399	37	34	38	2	The title of the section is emissions in trade. There is no need to mention about the majority of the China's emission. For most countires, the majority emisison is domestic emission.	Accepted and revised.	Shiyan	Chang	Tsinghua University	China
47657	37	8			Fig 2.12 - need to use constant USD 2015 across report	Rejected. This is based on the available literature and the data that is used in those sources.	Slade	raphael	Imperial College	United Kingdom (of Great Britain and Northern Ireland)
2313	38	3	38	3	Hard to distinguish colors combined with disordered legends make Figure 2.13 difficult to read	Accepted and revised.	Martinerie	Patricia	CNRS	France
15945	38	3	38	3	In Figure 2.13, please be more specific with "other services", describe it and why after a) not b) but e)	Accepted and revised.	Takarina	Noverita	Universitas Indonesia	Indonesia
36445	38	9	38	9	Write out EET once here with abbreviation given in parentheses	Accepted and revised.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
35853	38	26	38	27	US is the largest importer of embodied emissions, particularly from China. Please check line 23-25 on Page 40.	Accepted and revised.	Gupta	Himangana	Institute for the Advanced Study of Sustainability, United Nations University, Tokyo	Japan
18397	38		38		no b in Figure 2.13	Accepted and revised.	Shiyan	Chang	Tsinghua University	China
36447	38	8	40	11	Although this section very nicely reflects Asias and especially Chinas role for exported emissions I am wondering how and why tradeflows to North America and Europe are not included and shown relative to the South-south transfers. As it is displayed now the potentially main trade flows are not included or put in relation. As long as not ‘traditional’ main trade flows to Europe/USA are included I am wondering what is the use of the information given here for the global perspective. It would be great to have a figure to see; as stated in lines 6-9 this shift of China away from Europe and USA to Africa	Accepted. The section is rewrote. Not applied.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
41105	39	23	24	2	This para needs some further work and consistency check with WGI	Accepted. We need to make sure that relevant numbers from WGI are reflected in this section and inconsistencies are pointed out.	Fuglestvedt	Jan	CICERO	Norway
8781	39	23	39	24	The recent trade and emissions literature that has compared consumption-based emissions to territory-based emissions has found that trade did not impact territory emissions (e.g., Knight and Schor 2014; Fernandez-Amador et al. 2017; Lamb et al. 2014; Liddle 2018a and 2018b; Hasanov et al. 2018). (That trade should not impact territory-based emissions was shown theoretically as well in Liddle 2018b.) Furthermore, in both OECD and non-OECD countries, exports lowered consumption-based emissions, while imports increased consumption-based emissions (e.g., Liddle 2018a). Fernandez-Amador, O.; Francois, J.; Oberdabernig, D.; Tomberger, P. 2017. Carbon dioxide emissions and economic growth: An assessment based on production and consumption emission inventories. Ecol. Econ., 135, 269–279. Hasanov, F., Liddle, B., & Mikayilov, C. 2018. The Impact of International Trade on CO2 Emissions in Oil Exporting Countries: Territory vs. Consumption Emissions Accounting. Energy Economics, Vol. 74, pp. 343-350. Knight, K.; Schor, J. 2014. Economic growth and climate change: A cross-national analysis of territorial and consumption-based carbon emissions in high-income countries. Sustainability 2014, 6, 3722–3731. Lamb, W.; Steinberger, J.; Bows-Larkin, A.; Peters, G.; Roberts, J.; Wood, F. Transitions in pathways of human development and carbon emissions. Environ. Res. Lett. 2014, 9, 1–10. Liddle, B. 2018a. Consumption-based accounting and the trade-carbon emissions nexus. Energy Econ., 69, 71–78. Liddle, B. 2018b. Consumption-based accounting and the trade-carbon emissions nexus Asia: A heterogeneous, common factor panel analysis. Sustainability 10(10), 3627.	Accepted.	Liddle	Brantley	Energy Studies Institute, NUS	Singapore
6935	39	16			should it be 673 MT of global traded CO2 emissions?	Accepted and revised.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
35025	40	15	15	40	Delete "extra f"	Accepted but don't have spaces for a new figure.	Ehsan	Taghavinejad	NIOC	Iran
5191	40	15	40	15	"f" should be deleted.	Accepted and revised.	Alataş	Sedat	Aydın Adnan Menderes University	Turkey
15947	40	15	40	15	In sentence: EEE (emissions embodied in export) f, whereas; typo the letter f should be superscript	Accepted and revised.	Takarina	Noverita	Universitas Indonesia	Indonesia
26173	40	15	40	15	f (delete)	Accepted.	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
32303	40	17	40	19	Note that Switzerland is an outlier in this case. For most high income countries this ratio is between 1.1-1.4	Accepted and revised.	Kulionis	Viktoras	ETH Zürich, Ecological Systems Design	Switzerland
36451	40	13	40	25	Would be great to have this statements shown in a figure somewhere (instead Figures	Accepted and revised.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
15949	40	32	40	32	In sentence: importers of embodied carbon from poorer parts of the US; please mention what the poorer parts are?	Accepted and revised.	Takarina	Noverita	Universitas Indonesia	Indonesia
10339	40	12			This section feels repetitive following 2.3.3 and 2.3.2. Also the treatment of carbon leakage is far too brief and cursory here (p41 l 14 ff) - this needs its own space, not as a subset of trade.	Accepted.	Reisinger	Andy	NZAGRC	New Zealand
6937	40	16			with higher PBE as compared to CBE (to be precise; developing countries' PBE are in gernal not higher than those of developed countries)	Accepted and revised.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
18403	41	2	41	4	Not correct citation. Emission intensive is not mentioned in the report.	Accepted and revised.	Shiyan	Chang	Tsinghua University	China

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
32305	41	10	41	12	Developing countries might have less stringent environmental legislation and it might be one of the reasons for the shift but it should be clarified that usually environmnetal regulation plays a minor rule and there is no or very little evidence to support this claim. To some extent this also contradicts towhat has been said in Chapter 1 p21 line35-39. A good explanation on why countries relocate is provided by Hoekstra et al (2016): "As emphasized by Baldwin (2011), developments in information and communication technologies have facilitated the coordination ofproduction activities at a distance. Hence, the relocation of activities from high-wage countries to countries with lower wages has become even more profitable.While labour costs have always been the main driver ofrelo- cations, the North America Free Trade Agreement (NAFTA) negotiations in the early 1990s did spark an intense debate on whether unequal environmental regulatory standards and compliance costs across countries could be a source ofcomparative advantage for countries with loose regulations, which would thereby become 'pollution havens' (Daly, 1993). However, the empirical evidence – largely based on non-greenhouse gas (GHG) air pollutants data and environmental cost data – provided no or only weak support to the pollution haven hypothesis (PHH) (Grossman and Krueger, 1993;Wheeler, 2001;Jeppesenetal., 2002; Eskeland and Harrison, 2003;Brunnermeierand Levinson, 2004;Coleetal., 2005; He, 2006; Manderson and Kneller, 2012). The low share ofenvironmental cost in total cost is often pointed out as the reason for the weak empirical support for the PHH (Ederington et al., 2005)." Hoekstra, R., Michel, B., & Suh, S. (2016). The emission cost of international sourcing: using structural decomposition analysis to calculate the contribution of international sourcing to CO2-emission growth. Economic Systems Research, 28(2), 151-167.	Accepted.	Kulionis	Viktoras	ETH Zürich, Ecological Systems Design	Switzerland
35855	41	10	41	14	One reason is also the lack of strong carbon markets like in EU, which bars the industries to a particular amount of production.	Accepted	Gupta	Himangana	Institute for the Advanced Study of Sustainability, United Nations University, Tokyo	Japan
32307	41	31	41	31	Consider emphasising that hte biggest source of uncertainty is the underlying emissions data. Harmonizing territorial emissions across GMRIOs is the single most important factor that reduces uncertainty by about 50% (see a recent study on this by Tukker et al, 2020). Also note that while there is variation in absolute levels of emissions, trends across diferent databases are rather robust (again see Tukker et al 2020, for more details about this point). Tukker, A., Wood, R., & Schmidt, S. (2020). Towards accepted procedures for calculating international consumption-based carbon accounts. Climate Policy, 1-17	Accepted	Kulionis	Viktoras	ETH Zürich, Ecological Systems Design	Switzerland
5193	41	40	41	40	There is double dot. One of them should be deleted.	Revised	Alataş	Sedat	Aydın Adnan Menderes University	Turkey
6939	41	43	41	48	Another global account for consumption-based CO2 emissions is provided by Fernández-Amador et al. (2016; Ecological Economics; "Carbon dioxide emissions and international trade at the turn of the millennium"; http://dx.doi.org/10.1016/j.ecolecon.2016.01.005) - the updated data (including 2014) is availble upon request from the authors. The data covers the years 1997, 2001, 2004, 2007, 2011, and 2014, 78 countries/regions, and 57 sectors	Taken into account	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
6941	41	43	41	48	Fernández-Amador et al. (2020; Ecological Economics; "The methane footprint of nations: Stylized facts from a global panel dataset"; https://doi.org/10.1016/j.ecolecon.2019.106528) also provide global accounts for consumption-based CH4 emissions from 1997-2014 upon request. The country/sector/time coverage is the same as for their CO2 dataset. These datasetson CBE should be included in Table 2.2.	Taken into account	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
27387	41	27	42	10	the large discrepancies related to embodied land accounts could be introduced here: 10.1016/j.ecolecon.2013.12.003, 10.1016/j.landusepol.2015.09.022, 10.1111/jiec.12258	Rejected – beyond the mandate of the report	Erb	Karlheinz	Institute of Social Ecology, Univ. of Natural Resources and Life Sciences Vienna	Austria
10341	41	27			I struggle to see the value and relevance of this section, following on from the preceding one. It reads like a technical review of the authors' personal area of interest, with very limited links made to policy relevant conclusions that have not already been made in the preceding sections. As it stands I would encourage deletion of this section.	Noted, section revised to ensure relevance	Reisinger	Andy	NZAGRC	New Zealand
47659	41	43			"Six global accounts for consumption-based emissions" - would make sense to move this introduction to sources of data for CBE estimates to start of section	Accepted and rewrote the section.	Slade	raphael	Imperial College	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
24245	41	47			Definition of acronyms should appear at their first appearance (e.g., LULUCF).	Revised	Zhifu	Mi	University College London	United Kingdom (of Great Britain and Northern Ireland)
2315	42	3	42	6	The choice to restrict the analysis to fuel combustion whereas the carbon footprint concept aims at a more general view is deceiving	Rejected – the only comparisons to date are limited in scope	Martinerie	Patricia	CNRS	France
36455	42	8	42	8	In the caption it says '...sorted by increasing or decreasging trend of CBE'. This is wrong as apprearantly country diagrams are alphabetically sorted	Taken into account - text revised	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
13105	43	1	44	1	may be you may class thecountries according to the evolution pattern? I'm not shure the alphabetic ordenation is the best choice with so many figures	Taken into account - text revised	Fagel	Nathalie	AGEs, Departement of Geology, University of Liege	Belgium
30837	43	1	45	1	Figures 2.15 and 2.16 take up a lot of space and convey very little information. The 40 countries seem to have been chosen because that's all the data we have, but that doesn't mean we want to see it all. This feels like something that could be published separately and then cited. The badly-formatted excel blow-up of two graphs emphasises the irrelevance of the first figure - if we can't read the information from the original plots, why are we including them? Also, why is the legend different in this figure? Just presenting the 4 largest contributions, or the four most noteworthy plots, would make more impact. The summary plot in figure 2.17 conveys the message much more efficiently.	Accepted	Lamboll	Robin	Imperial College	United Kingdom (of Great Britain and Northern Ireland)
36453	44	2	44	2	Not sure I understand the intention of this figure and its interprestation: It is great to show that all the models for CBE show similar results and trends. But this only tells us something on the quality of the models but nothing else! Is that really relevant for this report? I expected rather that absolute outcomes and trends between the countries should be the main point here. For this relevant features that should be displayed is rather i) using the same CBE scale as this would allow to not only identify trends on similar scales but allow identifying highest and lowest CBE countries. Moreover, by caclualting ii) CBE per captia per country would allow to identify CBE between countries relative to their population size This would allow us to get a far more refined picture of main CBE numbers and allow better conclusions	Taken into account – combined with other comment	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
13103	44	3	44	4	the y axis may be adapted to better see the changes	Taken into account – combined with other comment	Fagel	Nathalie	AGEs, Departement of Geology, University of Liege	Belgium
47663	44	1			Figure 2.15 - CBE estimates for 40 countries - move to suplementary material?	Taken into account – combined with other comment	Slade	raphael	Imperial College	United Kingdom (of Great Britain and Northern Ireland)
36461	45	1	45	1	Unlcear why explicitly the combinationLuxembourg and USA is done for a comparison? Why is that useful?	Taken into account – combined with other comment	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
36457	45	5	45	7	'For the USA, the average absolute annual deviation from the multi-model mean CBE estimate is 2.7% compared to 24.7% for Luxembourg.' I) althought referred this cannot directly be seen in Fig 2.16 as numbers given in Figure are absolute and, ii) and a multi model mean is not shown. Why not include a multi-model mean in this/all diagrams? (all models = small grey lines, mult-model mean = thick colored line)	Taken into account – combined with other comment	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
30839	45	2	45	10	The text relating to the above figure keeps describing the errors in the smallest nations as largest. It needs to make clear that they are only largest proportionally, not in absolute terms. It's not clear to me that proportional error is important given that we will add all the consumption emissions together. It might also be more informative to consider per-capita emissions instead.	Taken into account – combined with other comment	Lamboll	Robin	Imperial College	United Kingdom (of Great Britain and Northern Ireland)
36459	46	5	46	10	Please make here or elsewhere clear why it is useful to discuss model output quality. What is the purpose ? Moreover, why is a model performing better if its closer to a calculated mean that has been estimated from (partly) its own outcome?	Accepted	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
28343	46	2			Instead of abbrevations perhaps better to use the names of countries	Editorial – copyedit to be completed prior to publication	Chan	Hoy Yen	ASEAN Centre for Energy	Malaysia
30841	47	1	47	1	The legend for figure 2.18 is incorrect regarding the grey dots. It's also very ugly.	Taken into account – combined with other comment	Lamboll	Robin	Imperial College	United Kingdom (of Great Britain and Northern Ireland)
38375	47	1	47	1	This entire section would be improved if you followed the Kaya Identity structure for your discussion.	Rejected – outside the scope of the chapter. Not supported by the peer-reviewed published literature	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
36463	47	4	47	16	CBE should be, by nature, be something, that could be determined by data that are converted. Using models can be useful to understand whether assumed interacting parameters do reflect trends and dynamics found in the data. Moreover, they can be useful for filling gaps and make future predictions. And no doubt that serveral models exist based on different assumptions. But why is is useful to have a sections on this model comparison and quality in the IPCC report is very unclear to me… I understand that one would need the models when there are no direct data available for estimation but I would have expected a comparison outcomes and what does this mean rather than discussion on the differences of outcome between models. This section should rather focus on mean outcomes and the range of uncertainty given by the models plus provide a better way of ranking and comparing outcomes and trends between countries. Additionally most of this section is very descriptive and does not through interpretation provide useful insights for CBE impacts on the global environment	Taken into account – combined with other comment	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
15951	47	14	47	16	You mention that: More work is required to understand….; then please explain why the recent work is not sufficient enough.	Accepted – text revised	Takarina	Noverita	Universitas Indonesia	Indonesia
2317	48	1	48	4	The huge impact of affluence as a GHG emission driver, illustrated by numbers much later (p75 l24-27 and p81 l47 - p82 l3) should be better described at the beginning of Section 2.4 because it is a major reading key to understand apparently weaker effects in the following subsections e.g. (regional, inequalities, urbanization etc).	Accepted – text revised	Martinerie	Patricia	CNRS	France
26177	48	4	48	4	Is it possible to elaborare more on the term " affluence"	Accepted – text revised	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
18415	48	4	48	6	why choose these three factors? Especially, the income and the affluen	Taken into account - text revised	Shiyan	Chang	Tsinghua University	China
42651	48	8	48	8	please say that we are looking again at production based emissions after the long discussion of CBE	Accepted – text revised	Eyckmans	Johan	KU Leuven	Belgium
6943	48	6	48	9	This directly contradicts the sentence in line 23-25. There is lots of evidence that on average (and if other factors are controlled for) there is relative decoupling of income and emisisons (e.g. Aichele and Felbermayr, 2012, "Kyoto and the carbon footprint of nations", doi:10.1016/j.jeem.2011.10.005; Aslanidis and Iranzo, 2009, "Environment and development: is there a Kuznets curve for CO2 emissions?", https://doi.org/10.1080/00036840601018994; or Fernández-Amador et al., 2017; Ecological Economics; "Carbon Dioxide Emissions and Economic Growth: An Assessment Based on Production and Consumption Emission Inventories"; http://dx.doi.org/10.1016/j.ecolecon.2017.01.004	Taken into account - text revised	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
26179	48	4	48	13	Elasticity emissions GDP elasticity depends also on the structure of the economy and prices particularly for extractives and fossil fuels exporting countries. Sharp fluctuations of mineral and oil commodities will have an important impact on the elasticity on the countries which rely on these products	Taken into account - text revised	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
8783	48	12	48	13	Liddle and Huntington (2020) confirmed that the income elasticity of energy is around 0.7 for both OECD and non-OECD countries in an analysis that controlled for energy prices (unlike Stern 2019). Liddle, B. & Huntington, H. 2020. Revisiting the income elasticity of energy consumption: a heterogeneous, common factor, dynamic OECD & non-OECD country panel analysis. The Energy Journal, Vol 41 (3).	Taken into account - text revised	Liddle	Brantley	Energy Studies Institute, NUS	Singapore
30463	48	14	48	14	This is a really important point, but it does not seem well articulated in the opening bold summaries, especially as much being said here is linked to RE, but RE was not included in some lists (see comments above).	Accepted – text revised	Cook	Lindsey	Quaker United Nations Office / Friends World Committee for Consultation (IPCC Observer)	Germany

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
38377	48	14	48	17	This sentence fails to include improvements in energy efficiency (or reductions in energy intensity) that result from improvements in technologies or practices. For this reference: Wang, R., V. A. Assenova, and E. Hertwich, 2019c: Empirical Explanations of Carbon Mitigation During Periods of Economic Growth. SocArXiv,. (this citation needs to be improved), I cannot find a published, peer-reviewed version of this on-line. Has it been peer-reviewed and published? If not, then it would be better for to find another citation to use. Regarding this reference: Dong et al. 2019: the Highlights section states "Energy intensity is the most significant factor in inhibiting global emissions." The Abstract states "The results suggest that the key driving force responsible for promoting global emissions from 1980 through 2015 is income, while energy intensity is the most significant factor in inhibiting global emissions." Thus, I think that if you use the one peer-reviewed, published article (Dong et al. 2019), this sentence must be changed to discuss the role of energy efficiency. Further, you make this statement on the same page, lines 31-35: "Global economic growth is the dominating driving force for the continued increase of global GHG emissions (especially in fossil-fuel rich countries (Burke et al. 2015), (Stern et al. 2017)), while a decreasing emission intensity caused by the improvement of energy efficiency and technology innovation contributes significantly to emission reduction (Liu et al. 2019c), (Chang et al. 2019), (Dong et al. 2019), (Sanchez and Stern 2016), (Mohmmed et al. 2019). These two sentences (lines 14-17 and lines 31-35) need to be resolved because they say different things. The second one (lines 31-35) provides many more references.	Taken into account - text revised	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
8785	48	18	48	20	There are two obvious reasons not to expect an inverted-U for carbon emissions. First, carbon emissions are a global pollutant whose impact is uncertain and spatially and temporally diverse—very different from a local pollutant with immediate, understood impacts. Second, carbon emissions are highly associated with energy consumption, and as mentioned above (Page 2-48, Lines 12-13), income and energy consumption are strongly related.	Accepted – text revised	Liddle	Brantley	Energy Studies Institute, NUS	Singapore
8787	48	18	48	20	Liddle and Messinis (2018) found very little evidence of inverted-U/V for individual OECD countries in an analysis that accounted for the statistical and modeling issues discussed on Lines 20-24 and considered very long-run data (1870-2010). Liddle, B. & Messinis, G. 2018. Revisiting carbon Kuznets curves with endogenous breaks modeling: Evidence of decoupling and saturation (but few inverted-Us) for individual OECD countries. Empirical Economics, Vol. 54, pp. 783-798.	Accepted – text revised	Liddle	Brantley	Energy Studies Institute, NUS	Singapore
4971	48	23	48	23	Should be: "Suffer from omitted variables bias"	Accepted – text revised	Stern	David	Australian National University	Australia
42649	48	23	48	23	omitted variable bias?	Taken into account – combined with other comment	Eyckmans	Johan	KU Leuven	Belgium
24841	48	24	48	24	Delete "(and are in line with fossil fuel use)"	Accepted – text revised	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
11721	48	23	48	25	"Globally,GHG emissions show relative decoupling from GDP (and are in line with fossil fuel use)". Comment: In fact, there is no historical global precedent for absolute decoupling of energy-GDP: There wasn't a single year 1971-2015 at a global level that has existed outside of relative energy-GDP decoupling - see Figure 1, Heun and Brockway (2019). full ref: Heun, M. K., & Brockway, P. E. (2019). Meeting 2030 primary energy and economic growth goals: Mission impossible? Applied Energy, 251, 112697. https://doi.org/10.1016/j.apenergy.2019.01.255	Accepted – text revised	Brockway	Paul	University of Leeds	United Kingdom (of Great Britain and Northern Ireland)
6947	48	14	48	30	Some studies find that although there is no EKC pattern in panel data, there is a decrease in the income-elasticity of emissions in higher income regimes. This could be included in the discussion. For literature see e.g. Aslanidis and Iranzo, 2009, "Environment and development: is there a Kuznets curve for CO2 emissions?", https://doi.org/10.1080/00036840601018994; or Fernández-Amador et al., 2017; Ecological Economics; "Carbon Dioxide Emissions and Economic Growth: An Assessment Based on Production and Consumption Emission Inventories"; http://dx.doi.org/10.1016/j.ecolecon.2017.01.004	Accepted – text revised	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
24843	48	32	48	32	Delete "especially in fossil-fuel rich countries"	Accepted – text revised	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
32309	48	37	48	38	Consider clarifying this sentence. Economic growth and change in the level of consumption and investments is more or less the same thing. Use one of them not both.	Accepted – text revised	Kulionis	Viktoras	ETH Zürich, Ecological Systems Design	Switzerland
4973	48	1	48	42	This page is repetitive - editing could shorten it.	Accepted – text revised	Stern	David	Australian National University	Australia
24845	48	41	48	44	Delete "Economic growth in the road transport … carbon intensity."	Accepted – text revised	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
30465	48	44	48	46	Since RE is shockingly only listed once in the intro summary highlights, and even then not in bold, the sentence on this page offers an excellent quote for the intro bold, specifically: The strong growth of renewable energy provision in some countries played a minor role in slowing down emissions growth at the global level (Peters et al. 2017b) and fossil CO2 emissions from energy use and industry reached a record high of 37.5 Gt CO2 in 2018	Accepted – text revised	Cook	Lindsey	Quaker United Nations Office / Friends World Committee for Consultation (IPCC Observer)	Germany
18063	48	3	50	19	In this discussion of drivers I miss an assessment of the role of the buildup of material stocks in the form of buildings, settlements, machinery and infrastructures as driver of future emissions. Industrial Ecology has recently made huge progress in analyzing the role of "manufactured capital" or "material stocks" in influencing future patterns of resource use, e.g. Weisz et al. 2015, PNAS 112, 6260–64. Pauliuk/Müller, 2014. Global Environmental Change 24, 132–142; Hertwich et al. 2019, Env Res Lett 14, 043004; Krausmann et al. 2017, PNAS 114, 1880-1885; Krausmann et al., 2020, Global Env. Change, 61, 102034, Haberl et al., 2019, Nature Sustainability 2, 173-184, and many others. I think this section could really benefit from broadening the perspective beyond "GDP drives everything", and also include such social-metabolism respectively industrial ecology perspectives. I note that some but not all this literature is discussed later (in section 2.8), so perhaps this comment can partially be resolved by more explicitly cross-referencing this section (I may have missed such cross-refs, but still I think that the impression that only GDP growth were relevant in driving aggregate emissions is too narrow)	Taken into account – text revised. This section was completely rewritten with a more consistent evaluation of drivers in regions and sectors. Material stocks included in Buildings sector (subsection 2.4.2.) and cross-referencing to Section 2.7 on committed emissions.	Haberl	Helmut	Institute of Social Ecology, University of Natural Resources and Life Sciences, Vienna	Austria
24089	48	3	50	19	This section or chapter could contain an analysis about the impact of the 2008-2009 global economic crisis (or other regional economic crisis) on emissions and environmental policy. It is important to summarize knowledge about these situations (with opportunities and adverse side effects). This does not seem to be present in AR6 WGIII FOD. Many papers have been written on that subject, both at regional/sectoral and global level (see e.g. : https://www.sciencedirect.com/science/article/abs/pii/S0301421514004480. https://link.springer.com/article/10.1007%2Fs10436-019-00356-x. https://doi.org/10.1038/nclimate1332. https://academic.oup.com/oxrep/article-abstract/26/2/137/365465?redirectedFrom=fulltext)	Rejected – beyond the mandate of the report	Lecocq	Noé	Inter-Environnement Wallonie	Belgium
5175	48	1	59	48	Section 2.4 analyses underlying drivers of GHG emissions. To this end, it decomposes the changes in GHG emissions into several factors, such as techno-economic, socio-demographic factors, (i.e. education, age or household size) poverty, inequality, urbanisation and trade, and discusses their impacts on GHG emissions in detail. However, as discussed recently by many researchers including Allwood et al. (2011), Aidt et al. (2017), Hernandez (2018) or Barret et al. (2019), demand for material might be highly important factor for GHG emissions as most of energy is embedded in metarial. Therefore, demand for material might lead to a greater increase in energy use and emissions. Data also confirms these concerns. For example, International Resource Panel (IRP) Report for the United Nations Environment Program (UNEP) (2016) states that primary material extracted increased from 22 billion tonnes in 1970 to 70 billion tonnes in 2010. More importantly, emissions from the production of materials as a share of global GHGs increased from 15% in 1995 to 23% in 2015. According to recent report of IRP (2020), the material use will further increase from current levels of 90 million tons to 190 million tons, leading to GHG emissions to increase by %43. We can, therefore, suggest that environmental impact of material use on the planet seems to further increase in the near future. Based on these discussions, I recommend to expand this section with material use and its effect on GHG emissions.	Taken into account – text revised	Alataş	Sedat	Aydın Adnan Menderes University	Turkey

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
16203	48	1	59	48	Consider adding a section 2.4.6 Global Militaries as a Driver for GHG Emissions to highlight how increased militarization affects GHG emissions.	Rejected – beyond the mandate of the report [no sufficient data is available to quantitatively assess the influence of military activities (though it would certainly be interesting to analyse that)	Helman	Daniel	College of Micronesia-FSM	Micronesia, Federated States of
17629	48	1			Somewhere, and perhaps it sits best in this section, the chapter should consider price and costs and drivers. Notably, the long-run elasticity of energy demand w.r.t. price appears to be close to -1 – ie. cumulative responses in technology and structure tends to adapt. Which also implies that the overall cost of energy provision has tended to revert to long-run constancy, despite wide variations in prices between countries. See: Igor Bashmakov et al, "Minus 1" and energy costs constants: empirical evidence, theory and policy implications, in review with Applied Energy. The underlying analysis is available in a prior working paper: M.Grubb, I.Bashmakov, P.Drummond (June 2017), Minus 1: Empirics, theory and implications of the 'Bashmakov-Newbery Range of Energy Expenditure', Final report to INET; https://www.ucl.ac.uk/bartlett/sustainable/publications/2018/apr/exploration-energy-cost-ranges-limits-and-adjustment-process	Taken into account – text revised	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
10343	48	3			Section 2.4.1.1 has a lot of repetition of general statements, while at the same time many contraditions. If the emissions-GDP elasticity is about unity p48 line 8), how come there has been relative decoupling of GHG emissions from GDP as per p48 line 24? Also, is the statement on page 49 line 1 consistent with the data in section 2.2.2? Page 49 line 21 says CO2 emissions decreased by 0.5% in OECD countries. Another apparent inconsistency is that page 49 line 19 says energy intensity has declined in developing countries, but then line 26 same page says energy intensity has risen? Please reduce confusion by using consistent metrics and cross-referencing statements already made elsewhere in this chapter.	Accepted – text revised	Reisinger	Andy	NZAGRC	New Zealand
6945	48	22			I do not understand the meaning of the sentence starting in line 21 and ending in line 23.	Accepted – text revised	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
15109	48	23			After "unidentified time effects (Stern 2018)." it is suggested to add: "Global trend patters, when perceived on the basis of a sequence of saturation curves ('blossoming evolution') promise explanatory power in the long run (Ahamer, 2018)." -- The reference is: Ahamer, G. (2018), Applying Global Databases to Foresight for Energy and Land Use – the GCDB method. Foresight & SDI Governance, 14(4), 46-61. DOI: 10.17323/2500-2597.2018.4.46.61	Rejected – outside the scope of the chapter. Not supported by the peer-reviewed published literature	Ahamer	Gilbert	Environment Agency Austria	Austria
35021	49	3	4	49	The sentence that reads "More Substantial…" is suggested to be deleted as fossil fuels could be used in the CCS technology.	Taken into account – text revised	Ehsan	Taghavinejad	NIOC	Iran
24847	49	3	49	4	Delete "More substantial emissions reductions … Le Quere et al. 2019b)."	Taken into account – combined with other comment	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
15953	49	11	49	14	In sentence: Figure 2.19 Kaya decomposition of main drivers of global emissions growth between 1990 and 2018 (changes relative to 2000) (Source: Global Carbon Project)Figure 2.19 shows kaya decomposition of global emission drivers between 1990 and 2018.; please re arrange this sentence since it is confusing.	Accepted – text revised	Takarina	Noverita	Universitas Indonesia	Indonesia
24849	49	13	49	14	Delete "Figure 2.19 shows … and 2018."	Accepted – text revised	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
38379	49	11	49	18	This could be improved by introducing the key elements of the Kaya Identity: CO2 emissions = population x GDP/capita x energy/GDP x CO2/energy (Kaya, Y., 1989. Impact of Carbon Dioxide Emissions on GNP Growth: Interpretation of Proposed Scenarios, Geneva, Intergovernmental Panel on Climate Change, Response Strategies Working Group). The figure plots components of this (energy/GDP and CO2/energy), but fails to plot population and GDP/capita instead plotting GDP, energy, and fossil CO2. I find this very confusing and expect other readers familiar with the Kaya Identity will also. This should be better explained here.	Accepted	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
29069	49	15	49	18	Was population not a factor at all? Might be worth showing population as well since all other Kaya factors are shown	Accepted	Shukla	Priyadarshi	Ahmedabad University	India

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
38381	49	22	50	1	These are very broad and sweeping statements that rely on only one reference. I think that you need to provide additional evidence if you are making such broad statements. This report is supposed to be a survey of the literature. Citing only one reference for statements of this magnitude seems tenuous.	Accepted – text revised	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
6949	49	6			carbon intensity: of energy or of GDP? (this question appears also later in the text as e.g. In line 19...)	Accepted – text revised	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
6951	49	7			carbon intensity is the least influential factor for global CO2 emissions (out of which factors?)	Accepted – text revised	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
6953	49	11			That decrease in emissions per unit of GDP in 2009 was only temporary and there was an upward change in emission intensities after 2009 -- after 2009 up to which year? The CO2 emissions database available from Fernándze-Amador et al (2016) shows a decrease in the global CO2 intensity of value added between 2004 and 2007 and a slight increase between 2007 and 2011, but it also shows that this was followed by a pronounced decrease again between 2011 and 2014. Also other databases covering global emissions may show such an decrease in the CO2 intensity of value added (or GDP) after 2011.	Accepted – text revised	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
6955	49	17			The Kaya decomposition should be explained. It is not clear from the text or the graph what is decomposed in which components. It seems that there are two decompositions: 1. Fossil CO2 is decomposed into CO2/energy * Energy/GDP * GDP, and 2. Energy is decomposed into Energy/GDP * GDP. This should at least be shortly explained. Also, on page 50, line 7 changes in population are mentioned. Thus, instead of adding GDP in the decompositon as the last term it would be informative to add GDP/population (i.e. gdp per capita) * population as additional terms.	Taken into account – combined with other comment	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
11723	50	1	50	3	"The emissions-reducing effects of energy efficiency improvements are also diminished by the energy rebound effect, which was found to completely offset any energy savings (Bruns et al. 2019), (Rausch and Schwerin 2018)." Comment: For developing countries, the study by Heun and Brockway (2019) provides the first empirical study to show that gains in (thermodynamic) efficiency are linked to gains economic growth - see FIgure 9, and for Ghana there is ample 'efficiency headroom' to allow rapid economic growth with associated rises in energy use.	Accepted – text revised	Brockway	Paul	University of Leeds	United Kingdom (of Great Britain and Northern Ireland)
38383	50	1	50	3	Both references for this statement are working papers, which are presumably unpublished and not yet peer-reviewed. Are these acceptable publications for the IPCC AR6? The analyses presented in these two papers are for the US only. Thus, the statement "The emissions-reducing effects of energy efficiency improvements are also diminished by the energy rebound effect, which was found to completely offset any energy savings" needs to be modified to say that this is for the U.S. during the 1960-2011 and 1992-2016 periods only. As it stands, the reader might expect that this analysis covers the world or at least covers a representative number of countries/economies.	Accepted – text revised	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
46455	50	12	50	19	This data is outdated, ending at 2009 — before the natural gas revolution has changed everything. The technological revolution allowing for firms to extract far more natural gas from shale and the ocean floor is the main reason that U.S. carbon emissions from energy declined 13 percent between 2005 and 2018, and a big part of the reason why global temperatures are unlikely to rise more than 3 degrees centigrade above pre-industrial levels. You appear to bury this point at the end of a paragraph on page 52, when it should be highlighted in the summary and earlier, so as to not be misleading.	Taken into account – text revised	Shellenberger	Michael	Environmental Progress	United States of America
45723	50	30	50	32	Analysis of 18 developed peak-and-decline countries, including the USA and 17 European countries, showed that decreases in energy use and increases in the share of renewable energy were the main drivers of a decline in territorial emissions (Le Quéré et al. 2019b). >Above mentioned literature says renewable energy were the main driver of a decline of emission but figure on p2-51 shows the energy intensity of GDP contributes a major reductions of emission in European countries.	Accepted – text revised	Ogawa	Junko	The Institute of Energy Economics, Japan	Japan
15955	50	32	50	32	In: sdrivers of a decline in...; sdrivers is typo changed it into drivers	Editorial – copyedit to be completed prior to publication	Takarina	Noverita	Universitas Indonesia	Indonesia
42653	50	35	50	35	drop "for" at end of sentence	Accepted – text revised	Eyckmans	Johan	KU Leuven	Belgium

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
46457	50	30	50	36	It is misleading to, on the one hand, ackowledge de-industrialization as a reason for lower emissions and, on the other, credit lower energy use and renewables, while giving no credit to natural gas. Natural gas reduced emissions 11 times more than solar energy and 50 percent more than wind energy in the U.S. And the unreliable nature of renewables means that they do not substitute for fossil power plants like nuclear plants do and instead must be backed up by natural gas or hydro-electric dams. It is impossible to credit unreliable solar and wind for emissions reductions without noting their total dependence on natural gas. France is a perfect example of why adding unreliable solar and wind to the electricity grid can actually make a clean grid worse. After investing $33 billion during the last decade to add more solar and wind to the grid, France now uses less nuclear and more natural gas than before, leading to higher electricity prices and more carbon-intensive electricity. French grid operator RTE-France publishes hourly historical data for electricity production from 2012 onwards, including an hourly carbon intensity rate useful for calculating annual carbon intensity averages. Since carbon intensity hit a minimum of 41 grams of CO22014, much higher natural gas, wind, and solar electricity has accompanied declining nuclear.	Taken into account – combined with other comment	Shellenberger	Michael	Environmental Progress	United States of America
6957	50	17			I do not understand the meaning of the sentence starting in line 17 and ending in line 18.	Accepted – text revised	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
10345	50	21			The discussion of drivers revisits the CBE-PBE issue and therefore feels repetitive to previous sections.	Taken into account – text revised	Reisinger	Andy	NZAGRC	New Zealand
36465	51	5	51	20	This section is partly repetition of content said in earlier sections; either remove of refer to these	Taken into account – text revised	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
13107	51	18	51	20	could you explain the link between CH4 and mining? No link with CO2?	Accepted – text revised	Fagel	Nathalie	AGEs, Departement of Geology, University of Liege	Belgium
11725	51	17	51	24	Comment: The offshoring effect was much more pronounced in 2000-2010 period than 2010-2020, and is decreasing as economies like the UK are 'bottoming out' such offshoring. This has implications for future CO2 reductions as "it is questionable whether further energy savings from structural change are forthcoming". (Hardt, L., Owen, A., Brockway, P., Heun, M. K., Barrett, J., Taylor, P. G., & Foxon, T. J. (2018). Untangling the drivers of energy reduction in the UK productive sectors: Efficiency or offshoring? Applied Energy, 223(March), 124–133. https://doi.org/10.1016/j.apenergy.2018.03.127. This supports the text lines 21-24 where final energy is now rising in the EU	Accepted – text revised	Brockway	Paul	University of Leeds	United Kingdom (of Great Britain and Northern Ireland)
38777	52	6	52	7	What is meant by “territorial”? Does this stat only including U.S. territories and not States (which are completely different categories)? Or, are these emissions stats national? Or only for a subset of U.S. states, such as the lower-48 or contiguous? It is unclear.	Accepted – text revised	Reyes	Julian	Personal Capacity	United States of America
45725	52	6	52	19	In the world's second largest emitter, the USA, territorial CO2 emissions decreased from a peak of 6.0 Gt CO2 in 2007 by 11% in 2013 (Feng et al. 2015) and by 12% in 2016 (Wang et al. 2019b). Because GDP grew by 19% between 2007 and 2016, this constitutes significant absolute decoupling. While population growth, investment and structural changes were driving emissions up, the factors driving down emissions included changes in per -capita consumption, production structure, fuel mix, energy intensity of GDP and consumption patterns (Feng et al. 2015) (Wang et al. 2019b). While the economic recession and an associated drop in consumption and capital investment was the main reason for the emissions decline earlier in the 2007 -2013 period, it seems that a shift from coal to natural gas in US electricity production and reduction in energy intensity play a more dominant role in later years up to 2015 (Feng 2019). The transportation sector slowed down the drop in overall emissions where as the 16 industry sector accelerated it (Wang and Wang 2019). Over the 50 -year period 1960 -2010, no support for the environmental Kuznets curve (EKC) hypothesis was found for the USA (Dogan and Turkekul 2016). One study found that cattle population density and affluence are strongly and positively correlated with state -level GHG emissions in the USA (Singh and Mukherjee 2019) . >It should be noted that in the United States, coupling has benefited greatly from the shale gas revolution, a shift from coal to natural gas at low cost.	Taken into account – combined with other comment	Ogawa	Junko	The Institute of Energy Economics, Japan	Japan

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
46461	52	6	52	19	This paragraph confuses declines in energy intensity with energy efficiency. They are two separate things. It would be clarified by the authors noting that energy leapfrog — the idea that high levels of prosperity can be achieved with little per capita energy consumption — has been repeatedly debunked. From a database from data on GDP, energy prices, and energy consumption from seventy-six countries. Arthur Van Benthem found no evidence of leapfrogging. Thanks to energy efficiency, things like lighting, electricity, and air conditioning are a lot cheaper. But that has just meant that people use them more, which reduces the energy savings that would have occurred had consumption levels not risen. Since 1800, lighting has become five thousand times cheaper. As a result, we use much more of it in our homes, at work, and outdoors. And by making cars cheaper, more people can buy them, increasing energy consumption. Van Benthem's finding wasn't particularly new. The fact that energy efficiency, a form of resource productivity, lowers prices, which increases demand, is basic economics. And economists demonstrated that cheaper lighting led to greater consumption in 1996 and again in 2006.	Accepted – text revised	Shellenberger	Michael	Environmental Progress	United States of America
18405	52	27	52	28	The study is quite old with the 2016 data as projection data.	Taken into account – text revised	Shiyan	Chang	Tsinghua University	China
38385	52	27	52	28	This out-of-date statement should be removed and replaced with current information since China's coal use continues to increase as of the end of 2019.	Taken into account – combined with other comment	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
4975	52	34	52	40	I think it is pretty clear from the emissions data that emissions haven't peaked in China. They increased by 2% in 2018 according to BP.	Accepted – text revised	Stern	David	Australian National University	Australia
38387	52	34	52	40	This information is also out-of-date and should be replaced with current information. China's CO2 emissions plateaued in 2015 and 2016, but have increased annually since then.	Taken into account – combined with other comment	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
29071	52	21	53	7	Section title is Asian and developing Pacific countries, so far largely focused on China. To check balance at SOD	Taken into account – text revised	Shukla	Priyadarshi	Ahmedabad University	India
15957	52	21	54	10	Why in the sub chapter of Drivers in Asian and developing Pacific countries, you only discuss China and India?. How about other South East Asian countries, Currently, there is growing discrepancy between Asian and SEA itself.	Taken into account – combined with other comment	Takarina	Noverita	Universitas Indonesia	Indonesia
10347	52	21			The treatment of different regions (and individual countries) feels very uneven. Nothing about LAM? Also what regional breakdown is being used here and why, compared to other parts of the chapter? A lot of the statements about basic drivers of growth seem repetitive rather than offering additional insights.	Taken into account – combined with other comment	Reisinger	Andy	NZAGRC	New Zealand
6959	53	1	43	2	There seems to be a contradiction: how can consumption patterns become one of the main moderating factor of emissions while consumption also remains one of the dominating factor driving up emissions?	Accepted – text revised	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
29073	53	7	53	9	Not sure if table adds that much value. The narrative above the table is more useful	Taken into account – text revised	Shukla	Priyadarshi	Ahmedabad University	India
35023	53	16	53	16	Delete "," before the word Iran, and delete ")"	Editorial – copyedit to be completed prior to publication	Ehsan	Taghavinejad	NIOC	Iran
4977	53	13	53	19	This discussion on South Asia should be improved or deleted - it's unclear what the methods of these studies are. This section should consistently use decomposition (which isn't necessarily causal) to assess drivers or be specific about deeper causal factors.	Accepted	Stern	David	Australian National University	Australia
8789	53	13	53	19	One should be careful in citing/reading in too much from studies that use energy consumption to explain carbon emissions. Firstly, carbon emissions data are directly derived from energy consumption data. Secondly, Jaforullah and King demonstrate the statistical/modeling problems of including energy consumption in carbon emissions regressions. Jaforullah, M. and King, A. 2017. The econometric consequences of an energy consumption variable in a model of CO2 emissions. Energy Economics 63, 84-91.	Accepted – text revised	Liddle	Brantley	Energy Studies Institute, NUS	Singapore
6961	53	13			What does it mean that causality between per-capita income,GDP, energy consumption and CO2 emissions was found? Which direction of causality?	Accepted – text revised	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
24851	54	15	54	15	Delete "due to an increasing use of oil in the transportation sector"	Rejected – no scientific evidence/publication provided to support changes suggested by the reviewer	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
5195	54	15	54	16	Publication year should be added to the references.	Accepted – text revised	Alataş	Sedat	Aydın Adnan Menderes University	Turkey
2319	54	12	54	25	Middle East is not mentioned in the (short) Section 2.4.1.4 Drivers in Africa and the Middle East	Accepted	Martinerie	Patricia	CNRS	France

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
15961	54	12	54	25	Please elaborate more the sub chapter of Drivers in Africa and the Middle East since it is only 3 paragraph which is too short compared to other sub chapters previously.	Taken into account – combined with other comment	Takarina	Noverita	Universitas Indonesia	Indonesia
17357	54	12	54	25	Sanctions should be considered as an effective factor in increasing greenhouse emissions in some countries. Sanctions in two respects increase carbon emissions. First, it prevents the country from accessing the resources needed to invest in decarbonization projects. Second, it restricts or impedes the country's access to the necessary technologies for carbon mitigation. For example, Iran's inaccessibility of export-led funds reduce the investment potential for the construction of combined cycle power plants. Under these conditions, the country will have to build lower efficiency gas turbine power plants that increases carbon emissions.This is exacerbated by water scarcity caused by climate change. In addition, sanctions has ruled out the possibility of using high efficiency class H gas turbine technologies. In another example, sanctions have prevented Iran from investing in NGL projects to reduce its flue gas emissions.	Rejected – no scientific evidence/publication provided to support changes suggested by the reviewer	Sadegh	Zeyaeyan	Islamic Republic of Iran Meteorological Organization (IRIMO)	Iran
26181	54	12	54	25	In the case of Sub-Saharan Africa, the fast emissions rate must be qualified given the very low of emissions in absolute values. In the case of South Africa, decoupling and recoupling might be explained by the sharp fluctuations of the economic growth.	Accepted	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
46459	54	13	54	25	This paragraph is analytically and ethically suspect. Have the authors been to sub-Saharan Africa? Per capita income in Congo is $600/year. And the IPCC authors are worried Africa might use coal? Seriously? The average Congolese person consumes the energy equivalent of 1.1 kilograms of oil per day (kg/day). The average Indonesian consumes the energy equivalent of 2.5 kg/day. The average U.S. citizen consumes 19 kg/day. In the Congo, wood and charcoal constitute more than 90 percent of residential primary energy. Many demographers believe that how quickly the human population peaks and starts to decline, globally, depends on how quickly sub-Saharan nations like the Congo industrialize	Accepted – text revised	Shellenberger	Michael	Environmental Progress	United States of America
6967	54	23	54	25	A change from emissions first rising faster than GDP and then not rising with GDP at all seems striking. The reasons for that should be explained in further detail.	Accepted	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
15963	54	28	54	29	Please enrich the body literature to support this sentence: "emissions of GHGs are affected by demographic and social factors, such as education, age, household size..... There are numbers of literatures that can be used to enrich the causal factors of GHG. ex: Socio-Demographic Drivers of Residential CO_2 Emissions in the 47 Prefectures of Japan	Additional literature, including the study suggested has been included to enrich the discussion of effect of demographic factors on emissions.	Takarina	Noverita	Universitas Indonesia	Indonesia
2627	54	33	54	38	Since the issue is mitigation, the question arises for any driver to decide whether it must be considered as entirely exogen, or if one can do anything to modify it in a way favouring mitigation. For example, most technoeconomic drivers considered in 2.4.1 can be acted upon for mitigation purposes. This issue is adressed by a large part of this WG3 FOD Concerning the population size considered here, ways to act upon it are known to exist and to work. Let us quote education, particularly for girls, and help to birth control. Other tools might be explored, such as minimum allocations for old people. However they are nowhere discussed in this report. The minimum requirement compatible with a science attitude would be to indicate awareness of this silence and to give reasons for it.	Taken into account – text revised. In the discussion on how demographic structure and especially ageing of the population relates to emissions we include discussion of how policies related to age of retirement and working hours might influence mitigation efforts	Waldteufel	Philippe	CNRS/IPSL/LATMOS	France

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
45931	54	33	54	40	Saying that the population elasticity of emissions is about one is true but not much instructive. As O'Neill 2012 indicates, elasticities that differ from 1 imply that there is another variable that is influencing emissions (e.g. ageing : that could be linked to your next paragraphs) or that there are indirect effects of population on other variables. But this is a rather technical debate from the point of view of readers of an IPCC report: the reader ultimately needs to understand how the population of various regions and its change influence emissions. This is not clear in the sentence that says that elasticity "does not differ significantly between developed and developing nations". Of course doubling the number of humans in a society with low emissions roughly doubles the emissions, and it also applies to a society with high emissions. But a key is that a small increase in a population that emits a lot may have more impact on global emissions than a larger population increase in a population that emits little. If all countries become low or zero emissions, then it would not mean that population would not matter anymore, but that its role becomes more complex to assess (e.g. it may need a link with land-use and other resources, rather than just an elasticity of emissions). This needs a broader assessment of the literature - as you correctly says, it is an old story, several papers where published about it.	Taken into account – text revised	Marbaix	Philippe	UCLouvain, Belgium	Belgium
8791	54	41	54	46	Re discussion on aging and emissions—there is evidence that aging can lead to less driving/personal transport (Liddle and Lung 2010; Liddle 2011). Liddle, B. & Lung, S. 2010. Age-structure, Urbanization, and Climate Change in Developed Countries: Revisiting STIRPAT for Disaggregated Population and Consumption-Related Environmental Impacts. Population and Environment, Vol. 31, No. 5, pp. 317-343. Liddle, B. 2011. Consumption-Driven Environmental Impact and Age Structure Change in OECD Countries: A Cointegration-STIRPAT Analysis. Demographic Research, Vol. 24, Article 30, pp. 749-770.	Accepted – text now revised, additional references and discussions now included.	Liddle	Brantley	Energy Studies Institute, NUS	Singapore
6969	54	27	56	2	Here micro- and macro-economic drivers of emissions are somewhat mixed throughout the text. It may make sense to separate them a bit more clearly.	Taken into account – text revise. This section was completely rewritten with a more consistent evaluation of drivers in regions and sectors	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
45929	54	27	56	2	This section needs substantial improvement: it currently appear as a compilation of various topics without sufficient analysis. Each paragraph should address a clear question and provide a clear synthesis of the main messages from the literature on this topic, so that the whole section provides a good overview of its subject.	Taken into account – combined with other comment	Marbaix	Philippe	UCLouvain, Belgium	Belgium
15959	54	1	59	1	This section that discuss various determinants of emission can be more attractive by adding some recent issues like: 1.How the Low Cost Carrier increase air transportation and lead to increase od emission, and 2. How emission differed according to gender.	Taken into account – combined with other comment	Takarina	Noverita	Universitas Indonesia	Indonesia
1279	54	13		22	this paragraph discuses about the CO2 trend in sub-saharan Africa. Is this meant to be CO2 concentrations or emissions?	Accepted – text revised	Anoruo	Chukwuma	University of Nigeria, Nsukka	Nigeria
6963	54	1			There are several studies on CH4 among others: for cross-sectional studies see e.g. Rosa et al (2004) URL: http://www.jstor.org/stable/4315539, Jorgenson (2006) https://doi.org/10.1353/sof.2006.0050; for panel studies e.g. Jorgenson and Birkholz (2010) :10.1016/j.ecolecon.2010.08.008, Zhang et al. (2018) https://doi.org/10.1029/2018EF000917; and papers by Fernández-Amador et al. (2018) https://doi.org/10.1016/j.econlet.2018.07.012, Fernandez-Amador et al (2019) https://doi.org/10.1080/00036846.2019.1676387, Fernández-Amador et al (2020) https://doi.org/10.1016/j.ecolecon.2019.106528 (see also literature on CH4 cited therein). If the focus here is on the Asia Pacific region, there are also some studies on methane specific for China e.g. Zhang and Chen (2019) https://doi.org/10.1016/j.enpol.2010.03.059,	Accepted – text revised	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
6965	54	2			What does "the total effects of N2= emissions changes are positive" mean?	Taken into account – text revised	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
10349	54	27			Thhis section overlaps strongly with chapter 5, and I'm not convinced that it all needs to be here. My sense is this chapter should focus more on the hard numbers rather than interpretations of causality, because it really doesn't do justice to the relevant literature or even tries to do a proper assessment. This is problematic because it lends itself to overly simplistic conclusions (that the chapter doesn't necessarily make itself, but it allows the reader to make them). Please discuss with chapter 5 what that chapter covers, and what is more relevant for chapter 2.	Taken into account – text revised. This section was completely rewritten with a more consistent evaluation of drivers in regions and sectors.	Reisinger	Andy	NZAGRC	New Zealand

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
45923	55	1	55	14	This paragraph is not sufficiently clear and instructive. In particular, the last sentences seem to contradict the first ones: what is meant by "ageing could have a negative effect on emissions" ? I assume that the reader of an IPCC report would think that "a negative effect on emissions" mean that they will increase with ageing, even more so because that is what would be consistent with the beginning of the paragraph. But that is not at all what is found in Wei et al 2018: this paper suggests that elderly people contribute to less emissions, as compared to the average population, because they contribute less to GDP. Please ensure that the paragraph is clear and consistent.	Taken into account – text revised	Marbaix	Philippe	UCLouvain, Belgium	Belgium
44399	55	19	55	20	There are risks of the sharing economy that may counteract the benefits such as the rebound effect, by which there might be an increased overall consumption, an inadequate regulation with unfair competition in the market and lower tax revenues, and inequalities in access to products. The EU Environmental Foresight System (FORENV) – Final report of 2018-19 annual cycle – Emerging issues at the environment-social interface, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-09707-5, doi 10.2779/363227 Hüttel, A., Ziesemer, F., Peyer, M., and Balderjahn. I., 2018. To purchase or not? Why consumers make economically (non-) sustainable consumption choices. Journal of Cleaner Production, 8(1): 827-836. Jacobs, K., Petersen, L., Horisch, J., Battenfeld, D., 2018. Green thinking but thoughtless buying? An empirical extension of the value-attitude-behaviour hierarchy in sustainable clothing. Journal of Cleaner Production, 203: 1155-1169. Connolly, J., and Prothero, A., 2008. Green consumption life-politics, risk and contradictions. Journal of Consumer Culture, 8(1): 117–145. Additionally, collaborative consumption can fuel consumerism, rather than leading to more sustainable consumption. “If the sharing economy follows this pathway of corporate co-option it appears unlikely to drive a transition to sustainability.” Martin, C.J. 2016. The sharing economy: A pathway to sustainability or a nightmarish form of neoliberal capitalism? Ecological Economics, Volume 121: 149-159. https://doi.org/10.1016/j.ecolecon.2015.11.027. Total consumption in the EU has not decreased, as evidenced by Eurostat, 2019. Clothing and footwear statistics. European Commission, , https://ec.europa.eu/eurostat	Taken into account – text revised. Additional literature and more nuanced discussion of the sharing economy has been included in section 2.6 now.	Fra Paleo	Urbano	University of Extremadura	Spain
9205	55	31	55	32	Evidence of the importance of education to reduce vulnerability to climate change, and in particular to extreme temperatures can be found in the following references: Nunes, A.R. (2019). General and specified vulnerability to extreme temperatures among older adults. International Journal of Environmental Health Research, DOI: 10.1080/09603123.2019.1609655 Nunes, A.R. (2018). The contribution of assets to adaptation to extreme temperatures among older adults. PLoS ONE, 13 (11): e0208121. Additionally, there are proven links between education, health and well-being and the achievement of the sustainable development goals. See reference: Nunes, A.R., Lee, K. and O’Riordan, T. (2016). Rethinking the Sustainable Development Goals under a health and well-being framework. BMJ Global Health, 1 (3): e000068.	Taken into account - text revised. This text was moved to Section 2.6 and merged with other text there	Nunes	Ana Raquel	University of Warwick, UK	United Kingdom (of Great Britain and Northern Ireland)
45927	55	37	55	39	This sentence on social norms appears quite disconnected from the rest of the paragraph, does not have a reference, and does not appear to be an in-depth assessment of the topic. This should either be moved to section 2.7.2 or further explored. There certainly is literature on the topic, for example Alló, Maria, et Maria L. Loureiro. « The Role of Social Norms on Preferences towards Climate Change Policies: A Meta-Analysis ». Energy Policy 73 (1 octobre 2014): 563‑74. https://doi.org/10/ggf6pr.	Taken into account - text revised. This text was moved to Section 2.6 and merged with other text there.	Marbaix	Philippe	UCLouvain, Belgium	Belgium
6973	55	40	56	2	This paragraph mixes a lot of concepts: urbanisation, population density, as demographic trends, then a jump in room temperature, than other demographic factors such as gender and marital status... The different ideas should be better connected	Accepted – Most of this paragraph was deleted; only the two sentences on individual carbon footprints were moved to Section 2.6 on behaviour and lifestyles	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
45925	55	40	56	2	This paragraph lacks focus. It should focus on one aspect, such as urbanisation, and assess the role of this factor in an analytic way, based on several studies. In addition, Meangbua et al. 2019 is not used correctly: first, the 1°C increase that is referred to is not "room temperature" as indicated here, it is something like the average outdoor temperature (which gives a completely different message !). Moreover, the 200% increase needs a context. The paper indicates that this corresponds to 29 kg-CO2 per household, which is a very small amount (compare that to world average per capita emissions, assuming that it is for one year, which I could not find quickly in the paper but it seems to be so).	Accepted – Most of this paragraph was deleted; only the two sentences on individual carbon footprints were moved to Section 2.6 on behaviour and lifestyles	Marbaix	Philippe	UCLouvain, Belgium	Belgium
6971	55	15			What does "there is evidence on the separate effect of changes in household size on GHG emissions" mean?	Accepted – text revised.The sentence has been modified to explain the meaning more clearly.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
9645	56	5	56	19	Moreover, it is well understood in the literaturature that more equal societies attach a higher value to goods and services from the environment (Drupp 2018, Baumgärtner et al. 2017). This directly follows from the finding in the majoritiy of valuation studies, that the value individuals attach to environmental goods and services increases with income, but at a decreasing rate. References: Drupp, M.A., Meya, J.N., Baumgärtner, S., Quaas, M.F. (2018): Economic inequality and the value of nature. Ecological Economics, 150: 340-345.; Baumgärtner, S., Drupp, M.A., Meya, J.N., Munz, J.M., Quaas, M.F. (2017): Income inequality and willingness to pay for public environmental goods. Journal of Environmental Economics and Management, 85: 35–61.	Taken into account – text revised. We have included reference to the additional literature suggested and further discussion of this point regarding how the value people attach to environmental goods and services changes with rising income	Meya	Jasper	German Centre for Integrative Biodiversity Research	Germany
2321	56	47	57	3	The controversy commented is not sufficiently explained to be understandable without reading the papers and does not lead to a clear conclusion. Suppress?	Taken into account – text revised. The prominence of this one study that refutes the findings of many others has now been diminished and the long text related to it has been deleted.	Martinerie	Patricia	CNRS	France
15965	56	4	57	8	In sub chapter of Poverty and inequality as drivers of GHG emissions, please provide more examples and discuss poor countries from Africa, SE Asia	Taken into account – text revised. A much broader range of literature on poverty and inequality as a driver of GHG emissions has now been included in the draft. In particular, additional literature including evidence from African and SE Asian countries has been added (e.g. Baloch et al. 2020; Seriño et al.2019)	Takarina	Noverita	Universitas Indonesia	Indonesia
18065	56	4	57	8	Perhaps the recently published paper by Krausmann et al. 2020 Global Env Change 61, 102034 demonstrating the large role of inequality in terms of endowment with material infrastructures in different world regions for future GHG emissions could be helfpul in the context of this (or the next) section	Noted. Krausmann et al. 2020 make a very important point that certainly should be included in other parts of the report. However, as the focus here is on empirical evidence from ex-post studies, we do not include reference to the study here.	Haberl	Helmut	Institute of Social Ecology, University of Natural Resources and Life Sciences, Vienna	Austria
26183	56	4	57	8	In the case of sub-Saharan Africa and some Asian countries, inequality reduction for instance through better access to electricity and modern fuels has certainly increased emissions however fuel switching from firewood and charcoal and less deforestation had a tremendoud impact on decreasing emissions and increasing carbon sinks.	Taken into account – text revised. A more nuanced and extensive review of the literature has now been included in the draft. We also discuss how access to modern fuels and electricity forthe very poor have negligible implications for emissions growth	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
10351	56	4			From the discussion in this section, it's not always clear whether inequiality in itself is a driver for emissions, or simply the rise in upper incomes. The two are not the same and the causal links are not the same. I.e. is it more the total wealth that drives emissions, or the unequal distribution of wealth? The evidence presented really strongly supports only the former but it is presented in the context of the latter. Also much of this discussion is simply a review opf the literature, but not an assessment - having heard divergent results from different studies, what is your conclusion?	Taken into account – text revised. The section tries to focus specifically on the impacts of shifts in inequality and extreme poverty eradication on GHG emissions. While wealth and income are drivers in themselves, these are not the focus of this sub-section. We now provide a much broader review of the literature on this subject and provide a more nuanced assessment of the literature for different contexts and regions. We also provide a concluding paragraph at the end of the sub-section to discuss the implications of the empirical findings for the design of redistributive policies.	Reisinger	Andy	NZAGRC	New Zealand
6975	56	8			I do not understand the argument of the sentence starting in line 8 and ending in line 11	Taken into account – text revised [This sentence has now been redrafted to explain the argument being made more clearly. Further explanation is also provided]	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
24247	56	22			";" follwed by (Singh et al. 2017) should be removed.	Revised	Zhifu	Mi	University College London	United Kingdom (of Great Britain and Northern Ireland)
8793	57	11	57	11	I agree with the first part of the sentence: "Economic development and urbanization go hand in hand." However, I would suggest caution regarding the second half: "… and are both drivers of GHG emissions." Similarly, I think it is important to separate (i) papers that apply macro-carbon models and use share of people living in urban areas as an explanatory variable from (ii) papers that focus on the process of urbanization and employ more micro-based data. Studies along the lines (ii) might be very useful; however, I think the share of people living in urban areas likely adds little to our understanding of carbon emissions or energy consumption once income or GDP per capita is controlled for.	Accepted – text revised [Agreed. This section was substantially revised, making the distinction to urban living clearer (which is in Section 2.6) and focussing solely on the process of urbanisation]	Liddle	Brantley	Energy Studies Institute, NUS	Singapore
8795	57	11	57	11	The correlation between urbanization and emissions/energy is not necessarily causal, but rather, both are influenced by the same factors (e.g., the transformation from an agricultural economy to one dominated by industry and services). In other words, people move from rural areas to urban areas as agriculture becomes mechanized, and manufacturing and services—which tend to be located in urban areas—become the major employer. So, industrialization causes urbanization/rural-to-urban migration—at the same time that industrialization is fuelled by consumption of modern energy. As for putting urbanization on the RHS of an energy/carbon model, Liddle and Lung (2014) found more evidence that electricity consumption Granger-caused urbanization rather than the other way around. Liddle, B. and Lung, S. 2014. Might electricity consumption cause urbanization instead? Evidence from heterogeneous panel long-run causality tests. Global Environmental Change 24, 42-51.	Taken into account – text revised [ref. used to underpin the complexity of relationships but not elaborated as this section is specific to drivers of GHG emissions]	Liddle	Brantley	Energy Studies Institute, NUS	Singapore
29075	57	16	57	18	Carbon budget under which scenario	Accepted – text revised	Shukla	Priyadarshi	Ahmedabad University	India
24249	57	19	57	21	Please cite the relevant reference to justify this sentence.	Taken into account – text revised [this sentence was deleted]	Zhifu	Mi	University College London	United Kingdom (of Great Britain and Northern Ireland)
15967	57	27	57	28	You mention that: urbanisation between 1991 and 2013 had a small impact on CO_2 emissions….Hence I think it is better to discuss or add human migration issues that may have more significant impacts.	Taken into account – text revised [sentence was rephrased to make it clearer]	Takarina	Noverita	Universitas Indonesia	Indonesia
38389	57	37	57	41	This sentence is confusing - the large increases in affluence strongly competed? What does this mean? Can you be clearer?	Accepted – text revised [the whole paragraph was re-written to make it clearer]	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
38391	57	41	57	44	Either provide references or remove these sentences.	Accepted – text revised [sentences removed]	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
10353	57	10			Much of the text in this section is a literature review that presents divergent findings, but not an assessment - what is the conclusion? Also, correlation and causation isn't always clear; e.g. on page 57 lines 30-44 doesn't make it clear whether it is wealth that drives increasing emissions in urban areas, or urban lifestyles regardless of wealth? Is urbanisation the driver of emissions or just a way to increase wealth, and it is wealth that drives emissions?	Accepted – text revised [Agreed. This section was substantially revised, making the distinction to urban living clearer (which is in Section 2.6) and providing more of a synthesis of the literature]	Reisinger	Andy	NZAGRC	New Zealand
6977	57	42			What does "emissions locked in infrastructure" mean?	Accepted – text revised [sentences removed]	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
6981	58	2	58	5	This paragraph could be better explained	Taken into account – text removed [this part has been removed here as it is being dealt with in the 'urban living' section in 2.6]	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
8797	58	6	58	7	I am very skeptical about this analysis since urbanization almost never declines (see discussion/evidence in Liddle and Lung 2014).	Taken into account – text removed [this paragraph was removed since it was not central to the synthesis of literature in this section]	Liddle	Brantley	Energy Studies Institute, NUS	Singapore
18863	58	17	58	29	Karakaya et al. (2019) study specifically employs trade parameter (xmper) and found that while trade plays a significant role for consumption based emissions, there is no significant contribution on production based emissions for the annex 1 and non-annex countries. Please see Karakaya, E., Yılmaz, B., & Alataş, S. (2019). How production-based and consumption-based emissions accounting systems change climate policy analysis: the case of CO 2 convergence. Environmental Science and Pollution Research, 26(16), 16682-16694.	Taken into account – text removed [this part has been removed here as it is being dealt with in the 'urban living' section in 2.6]	Karakaya	Etem	Independent researcher, former Profesor,fired with the decree of law since 2016	Turkey

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
32311	58	33	58	33	Providing 18% number without any context is rather misleading. On its own 18% seems like a lot but when you compare it with other drivers e.g. consumption per capita is almost 10x higher i.e. 172% (this number is from Hoekstra et al, 2016 and it shows that the effect of the change in trade structure is almost an order of magnitude below the one of consumption per capita). Furthermore, the first study (which should be cited) to consider the trade structure effect for emissions was done by Arto and Dietzenbacher (2014) who reported the following: "We find that the changes in the levels of consumption per capita have led to an enormous growth in emissions (+14.0 Gt). This effect was partly offset by the changes in technology (−8.4 Gt). Smaller effects are found for population growth (+4.2 Gt) and changes in the composition of the consumption (−1.5 Gt). Changes in the trade structure had a very moderate effect on global emissions (+0.6 Gt) ....It follows from our results that this has hardly affected global GHG emissions. If the 2008 consumption bundle would have been produced with the 1995 import structure, global emissions would only have been 0.6 Gt less than the actual 39.3 Gt in 2008" Arto, I., & Dietzenbacher, E. (2014). Drivers of the growth in global greenhouse gas emissions. Environmental science & technology, 48(10), 5388-5394.	Taken into account – text revised [following this comment, we have now drawn a much sharper distinction between describing a shift in emissions (Section 2.3) and trade as a DRIVER of emissions (Section 2.4.5). We write: "This section describes how trade openness and liberalisation may have influenced global GHG emissions. .... The actual transfers of emissions embodied in trade are described in Section 2.3. In other words, this section only assesses whether trade changes the global level of emissions, but not whether it shifts emissions between countries or changes the level of emissions in individual countries (this is described in Section 2.3.3)." We have changed and moved paragraphs accordingly. We have also now tried to provide more assessment of the literature.]	Kulionis	Viktoras	ETH Zürich, Ecological Systems Design	Switzerland
36467	58	31	58	46	There is quite some repetition of insights from earlier sections. Perhaps remove here or shorten and reference there	Taken into account – covered in Policy Section [all articles that could be find on this topic were about carbon-related border tax adjustments or similar policies and prospective, and did not empirically evaluate whether trade has changed global GHG emissions levels. The following search term in WoS yielded 12 papers: ALL=(carbon OR CO2 OR GHG OR greenhouse) AND ALL=(emission*) AND ALL=(GATT OR "General Agreement on Tariffs and Trade") NOT ALL=ETS]	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
8799	58	31	59	19	The discussion in these sections would be the most inaccurately/incompletely assessed literature in the chapter. Again, I think there is substantial evidence that for trade to matter for emissions, one must consider consumption-based rather than territory based emissions—no matter the country group (e.g., Knight and Schor 2014; Lamb et al. 2014; Fernandez-Amador et al. 2017; Liddle 2018a and 2018b; Hasanov et al. 2018). Also, exports lower consumption-based emissions, while imports increase consumption-based emissions—no matter the country group (Knight and Schor 2014; Hasanov et al. 2018; Liddle 2018a and 2018b). Fernandez-Amador, O.; Francois, J.; Oberdabernig, D.; Tomberger, P. 2017. Carbon dioxide emissions and economic growth: An assessment based on production and consumption emission inventories. Ecol. Econ., 135, 269–279. Hasanov, F., Liddle, B., & Mikayilov, C. 2018. The Impact of International Trade on CO2 Emissions in Oil Exporting Countries: Territory vs. Consumption Emissions Accounting. Energy Economics, Vol. 74, pp. 343-350. Knight, K.; Schor, J. 2014. Economic growth and climate change: A cross-national analysis of territorial and consumption-based carbon emissions in high-income countries. Sustainability 2014, 6, 3722–3731. Lamb, W.; Steinberger, J.; Bows-Larkin, A.; Peters, G.; Roberts, J.; Wood, F. Transitions in pathways of human development and carbon emissions. Environ. Res. Lett. 2014, 9, 1–10. Liddle, B. 2018a. Consumption-based accounting and the trade-carbon emissions nexus. Energy Econ., 69, 71–78. Liddle, B. 2018b. Consumption-based accounting and the trade-carbon emissions nexus Asia: A heterogeneous, common factor panel analysis. Sustainability 10(10), 3627.	Accepted – text revised [removed repetition]	Liddle	Brantley	Energy Studies Institute, NUS	Singapore
15969	58	12	59	48	In discussing Trade as a driver of GHG emission, it is suggested to relate it with the global agreement such as General Agreement on Tariffs and Trade (GATT) and elaborate how GATT impact emissions	Noted (Agreed that the distinction between energy- and carbon-intensity is important. We follow and reflect the specific literature in this field).	Takarina	Noverita	Universitas Indonesia	Indonesia

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
8801	58	13	59	48	In general it is good to distinguish between energy intensive and carbon intensive. Some processes/manufacturing sectors are particularly energy intensive (e.g., chemicals, smelting), but carbon intensity has more to do with a country's energy system than a particular product or sector.	Taken into account - covered in Section 2.3 [The 'drivers of trade' section 2.4.5 only covers changes in GLOBAL emissions due to trade and therefore studies on individual countries or regions (Annex B in this case) are only covered in Section 2.3. We used this study to inform the PBE vs CBE policy box in Section 2.3]	Liddle	Brantley	Energy Studies Institute, NUS	Singapore
6979	58	1			What does "indirect CO2 emissions" mean in that context?	Taken into account – covered in Sections 2.3 and 2.4.1 [This is useful literature on consumption-based accounting and trade and we have aimed to take it into account in the section on CBE (Section 2.3). Also, some of the literature is useful for the section on economic growth and GHG emissions (Section 2.4.1). However, it does not fit in the 'Trade as driver' section (2.4.5) any longer as the scope of this section has changed such that it only deals with changes in GLOBAL emissions caused by trade, not with changes of (either CBA or PBA) emissisons in individual countries or groups of countries.]	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
10355	58	12			This section yet again discusses trade and emissions (following sections 2.3.3 and 2.3.4). Same comments as on those sections apply - set out a clear framework to understand the role of trade, and assess this in one place only please. Also much of this section is a literature review, where different and divergent findings are reported, but not an assessment - what are the authors' conclusions on the role of trade as a driver of emissions (or of emission reductions, depending on the carbon footprint of the traded goods in the producing and consuming countries)?	Accepted – text revised	Reisinger	Andy	NZAGRC	New Zealand
18435	58				The result of wang et al., 2018 is inconsistent with intuition. Please also cite other references to give a full picture of the judgement.	Taken into account – [inserted "the following:" to make it clearer that we mean the studies]	Shiyan	Chang	Tsinghua University	China
15971	59	10	59	11	In sentence: Studies finding that trade openness decreases territorial emissions include (Liobikiene and Butkus 11 2019)….include what? Should fix the sentence.	Taken into account – [checked]	Takarina	Noverita	Universitas Indonesia	Indonesia
24251	59	28	59	29	Please have a check.	Accepted – text revised	Zhifu	Mi	University College London	United Kingdom (of Great Britain and Northern Ireland)
5197	59	32	59	32	The sentence should be corrected as "Partly, this is due to the fact that non-OECD"	Accepted – sentence deleted	Alataş	Sedat	Aydın Adnan Menderes University	Turkey
18437	59	43	59	44	The citation is used out of context. The structure ajustment is not equal to shift the energy intensive industry to other countries. The structure adjustment is also a sign of demand shift.	Accepted – text revised	Shiyan	Chang	Tsinghua University	China
35027	59	46	59	46	Replace "calls" with "studies related to"	Taken into account – text revised [This section was combined with Section 2.4 and completely rewritten with a more consistent evaluation of drivers in regions and sectors]	Ehsan	Taghavinejad	NIOC	Iran
38393	60	8	60	19	Repeated comment from previous expert review: Without allocating the indirect (electricity and heat) emissions to the end-use sectors, the statements made here are relatively meaningless. The trends presented for the "energy sector" have very little meaning since the reader has no idea how or where this energy is being used (by which end-use sector). The indirect emissions currently attributed to the energy sector should be allocated to the end-use sectors where this energy is consumed in order to present a more meaningful and interesting description of energy and emissions trends. It is important to include both direct and indirect emissions when discussing the end-use sectors, as many policies are directed towards energy use and emissions from buildings, industry, and transport (that use both fuels and electricity). If the indirect emissions are not included, then policy advice is not based on the full picture and policy makers will have an incomplete understanding of the current status of each sector and the potential savings of policies directed towards those sectors. It is truly a disservice to present the information in this manner, especially when the IPCC touts itself as policy-relevant and publishes a Summary for Policymakers.	Taken into account – text revised [This section was combined with Section 2.4 and completely rewritten with a more consistent evaluation of drivers in regions and sectors]	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
22379	60	27	60	27	it is mentioned that carbon intensity of energy has been reduced to 478 gCO2/kwh, but without indicating when (what year) it occurred, since this indication is also very important and meaningful.	Taken into account – text revised [This section was combined with Section 2.4 and completely rewritten with a more consistent evaluation of drivers in regions and sectors]	Zhao	Xiusheng	Tsinghua University	China
22381	60	27	60	27	The unit of kilowatt hour in the expression of "from 526 gCO2/kwh in 2010 to 478 gCO2/kwh" should be written in a right way, that is, "kwh" should be given as "kWh" .	Taken into account – text revised [This section was combined with Section 2.4 and completely rewritten with a more consistent evaluation of drivers in regions and sectors]	Zhao	Xiusheng	Tsinghua University	China
26185	60	27	60	27	kwh must be written kWh	Taken into account – text revised [This section was combined with Section 2.4 and completely rewritten with a more consistent evaluation of drivers in regions and sectors]	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
38395	60	38	60	39	I encourage you to present both direct and indirect emissions here. If you don't add the indirect emissions, then this sentence should be changed to say "Direct GHG emissions in the industry sector…" If you don't add the indirect emissions, then perhaps you could at least tell the reader how much they were from the AR5 report so that there is at least an understanding of their magnitude? Note that the industry indirect emissions are presented in Chapter 11 (Industry) - perhaps you can include what is presented in that chapter here?	Taken into account – text revised [This section was combined with Section 2.4 and completely rewritten with a more consistent evaluation of drivers in regions and sectors]	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
38397	60	40	60	40	This phrase "along with energy demand and GHG emissions" makes no sense and should be removed.	Taken into account – text revised [This section was combined with Section 2.4 and completely rewritten with a more consistent evaluation of drivers in regions and sectors]	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
11727	60	22	61	9	Comment: There is no text in Chaper 2 on declining energy-return-on-investment of fossil fuel production, and its role as a driver of GHG emissions.This crosses both the energy sector paragraph, but also moves into industry energy para too, as its not just energy use for coal/oil/gas extraction, or power stations, but also oil & gas refineries and industries associated with production of finished fuels. The global EROI study of fossil fuels brockway et al (2019) suggests that EROI for global fossil fuels is much lower than thought, and declining. This has implications for GHG as a key driver, in that more energy will be required to produce future final energy. Ref: Brockway, P. E., Owen, A., Brand-Correa, L. I., & Hardt, L. (2019). Estimation of global final-stage energy-return-on-investment for fossil fuels with comparison to renewable energy sources. Nature Energy, 4(7), 612–621. https://doi.org/10.1038/s41560-019-0425-z	Taken into account – text revised [This section was combined with Section 2.4 and completely rewritten with a more consistent evaluation of drivers in regions and sectors]	Brockway	Paul	University of Leeds	United Kingdom (of Great Britain and Northern Ireland)
17177	60	1	62	5	Sub-chapter 2.6 completely ignores AFOLU / agriculture and LULUCF. This must be amended in the SOD.	Taken into account – text revised [This section was combined with Section 2.4 and completely rewritten with a more consistent evaluation of drivers in regions and sectors]	Rock	Joachim	Thuenen-Institute of Forest Ecosystems	Germany
16535	60	1	62	7	In Sectoral emission drivers, "Climate conditions" and "Land use change" should be mentioned and briefly considered. Even though, in chapter 7 (AFOLU) it partly have been reported.	Taken into account – text revised [This section was combined with Section 2.4 and completely rewritten with a more consistent evaluation of drivers in regions and sectors]	Jafari	Mostafa	Head of TPS for LFCCs/ and IPCC LA	Iran
1281	60	8		9	substantiate with literature and thereafter	Taken into account – text revised [This section was combined with Section 2.4 and completely rewritten with a more consistent evaluation of drivers in regions and sectors]	Anoruo	Chukwuma	University of Nigeria, Nsukka	Nigeria
17631	60	2			A good caveat! At the interface of sectoral emissions, drivers, and technologies, it might be interesting to look in depth at some notable cases. One obvious one would be the UK electricity sector, which has effectively eliminated coal and more than halved its emissions through a 3-pillar strategy of energy efficiency, renewable energy supports, and carbon pricing, as detailed in Grubb M. and D.Newbery (2018), UK Electricity Market Reform and the Energy Transition: Emerging Lessons, Energy Journal, Vol. 39, No.6, DOI: 10.5547/01956574.39.6.mgru	Taken into account – text revised [This section was combined with Section 2.4 and completely rewritten with a more consistent evaluation of drivers in regions and sectors]	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
38399	61	10	61	10	This sentence should be changed to say "Direct GHG emissions in the buildings sector…"	Taken into account – text revised [This section was combined with Section 2.4 and completely rewritten with a more consistent evaluation of drivers in regions and sectors]	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
38401	61	11	61	13	Thank-you for including the indirect emissions here! It would be more clear, though, if you provided the information for both direct and indirect CO2 emissions for 2010 and 2018 instead of only providing a percent growth for final energy use, while providing a total amount for the indirect (power) emissions. (Also, the word "Therefore" seems odd here - I suggest removing it).	Taken into account – text revised [This section was combined with Section 2.4 and completely rewritten with a more consistent evaluation of drivers in regions and sectors]	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
38403	61	25	61	25	I encourage you to present both direct and indirect emissions here. If you don't add the indirect emissions, then this sentence should be changed to say "Direct GHG emissions in the transport sector…" If you don't add the indirect emissions, then perhaps you could at least tell the reader how much they were from the AR5 report so that there is at least an understanding of their magnitude?	Taken into account – text revised [This section was combined with Section 2.4 and completely rewritten with a more consistent evaluation of drivers in regions and sectors]	Price	Lynn	Lawrence Berkeley National Laboratory	United States of America
11495	61	26	61	27	"GHG emissions growth in the transport sector has been driven by growing energy demand across all modes" - This is not true. I think Railway emissions has not increased. See https://www.climate-chance.org/wp-content/uploads/2019/12/en_c1_complet_def.pdf	Taken into account – text revised [This section was combined with Section 2.4 and completely rewritten with a more consistent evaluation of drivers in regions and sectors]	Gota	Sudhir	Independent Consultant/Researcher	India
11497	61	30	61	32	"Road transport emissions have grown despite a growth in electric car sales of about 2.5% due to the continued purchase of larger and heavier vehicles as well as the plummeting demand for more carbon-efficient diesel cars." - To call diesel cars as carbon-efficient is not appropirate. Research over past two decades have shown the impact of SLCP, the impact of diesel subsidy inducing more travel, impact of larger vehicles. etc. Carbon-efficient diesel cars is an oxymoron.	Taken into account – text revised [This section was combined with Section 2.4 and completely rewritten with a more consistent evaluation of drivers in regions and sectors]	Gota	Sudhir	Independent Consultant/Researcher	India
38037	61	28	61	34	I suggest to instert the following sentence: The rail transport has significant decarbonization potential. For example, in Hungary the carbon intensity of rail transport is less than 10% compared to road transport due to the electrification of the main railway lines and the relatively low fossil content of the Hungarian electricity mix. (Hortay and Pálvölgyi, 2020) Reference: Olivér Hortay, Tamás Pálvölgyi 2020 Driving forces in carbon dioxide emissions of the Hungarian transport sector Periodica Polytechnica Transportation Engineering (in print)	Taken into account – text revised [This section was combined with Section 2.4 and completely rewritten with a more consistent evaluation of drivers in regions and sectors]	Pálvölgyi	Tamás	Budapest University of Technology and Economics, Department of Environmental Economics	Hungary
18375	61	34	61	37	we can make a case study on analysis of transport energy intensity and emission intensity about China. In recent years, it took many powerful measures and demonstration work of transportation in many provinces and cities, results the rapid decline of energy intensity and emission intensity of transportation, it can be used as an important case for reference by other countries.	Taken into account – text revised [This section was combined with Section 2.4 and completely rewritten with a more consistent evaluation of drivers in regions and sectors]	Guo	Jie	China Academy of Transportation Sciences	China
26187	61	38	62	6	For emissions by fuel types better to use IEA (primary use)Thes emissions are already addressed in chapt 6 (6.3.1 p 11-12)	Taken into account – text revised [This section was combined with Section 2.4 and completely rewritten with a more consistent evaluation of drivers in regions and sectors]	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
24853	61		62		Figure 2.21 does not show in all panels data from 1970-2018	Taken into account – text revised [This section was combined with Section 2.4 and completely rewritten with a more consistent evaluation of drivers in regions and sectors]	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
16205	62	7	72	35	In Section 2.6 Technological Change, consider adding a subsection or brief treatment of the potential of drilling infrastructure from the oil/gas sector being used to develop wells and reservoirs for enhanced geothermal energy. Briefly, enhanced geothermal does not require endemic water resources nor is it restricted to tectonically active regions. Instead drilling is done with deep wells and heat extraction for electricity generation uses a closed-loop system typically with either water or CO2 as the heat transfer fluid. The development of appropriate drilling technology to develop enhanced geothermal wells and reservoirs is a current area of investment by, e.g. oil companies in Texas, and may provide an avenue for rapid energy transition. Oil and gas companies would have an incentive to transition to being primarily geothermal energy companies in some scenarios.	Rejected - outside scope of chapter - Ch6 covers energy technologies.	Helman	Daniel	College of Micronesia-FSM	Micronesia, Federated States of

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
18357	62	7	74	37	This covers technological change, key driver of future mitigation very well.	Noted	Hombu	Kazuhiko	Graduate School of Public Policy, The University of Tokyo	Japan
1283	62	1			not appropriate	Noted	Anoruo	Chukwuma	University of Nigeria, Nsukka	Nigeria
10357	62	7			Section 2.6 is well written, but it is mostly a text book. I'm looking for a concise assessment (not literature review) of evidence since the AR5. Missing is an assessment of how well historical forecasts of technology costs and deployment rates compare with actual outcomes (e.g. compare and contrast IEA forecasts with reality, but also past IPCC assessments - and understand the reasons for dynamic change). How well do we understand and can predict the pace and scale of technological change? This is a critical element for understanding realism of future scenarios assessed in chapter 3 and 4. There is also significant overlap with chapter 3; also a clearer hand-shake with the material covered in section 2.8 is needed.	Accpeted - text revised -We have added a section on this topic for SOD. We have also shortened the section by removing background and theoreticl lit some of which is now covered in ch16 and we include cross-refs to 16.	Reisinger	Andy	NZAGRC	New Zealand
17633	62	7			This section needs to be discussed with Chapter 16 (on which I have submitted quite extensive comments) I think most centrally, it needs to consider the specific metrics. Is it % contribution? % growth rates? Pace of cost reduction / competitiveness vis-à-vis incumbents? It may also be worth noting	Accepted - text revised - We have coordinated extensively with ch16. We now included ample cross refs to ch 16 and a new section includes key scale up metrics.	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
17179	63	16	62	17	Kaya identity is not explained in the glossary. Please add there.	Accepted - It has been added to Glossary	Rock	Joachim	Thuenen-Institute of Forest Ecosystems	Germany
15973	63	11	63	11	In sentence: durable-- can accelerate there is a typo--	Accepted - text revised	Takarina	Noverita	Universitas Indonesia	Indonesia
15975	63	15	63	15	In sentence: Technological change has facilitated the provision of more energy services; It should be changed to more diverse and efficient energy services.	Accepted - text revised	Takarina	Noverita	Universitas Indonesia	Indonesia
26189	63	22	63	24	This could be controversial unless substantiated and explained. Fig 222 shows a downwards trend of carbon intensity of energy supply	Accepted - text revised -clarified to "almost" no trend	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
6985	63	15	63	29	Much of this paragraph seems to be a repetition of page 2-49 ff. Redundancies should be removed. I suggest to keep the paragraph on p. 2-63 because it provides a better explanation than page 2-49 ff.	Accepted - text revised - have shortend considerably, esp the beginning section.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
6983	63	19			It seems that the CI of energy supply has fallen by one third over the past 100 years. The first 50 years in the graph look quite stable.	Accepted - text revised -This is a good observation suggested change is accepted. Last 100 years	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
36469	64	7	64	7	Is 'exnovation' a known term?	Yes it is a term in literature. Will add citations. Add to Glossary	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
15977	64	9	64	10	Comment to sentence: "countries may not have the capacity to absorb the flows of ideas and research results from international knowledge spillovers, due to..." Sometimes the new technology absorption is avoided since the use of new technology is too expensive.	Noted - but"access to credit facilities" includes "financial barriers"	Takarina	Noverita	Universitas Indonesia	Indonesia
15979	64	15	64	16	Comment to sentence: "Investment in low-carbon innovation depends on expectations of future market opportunities…."Please provide how much cost is needed to invest new technology,	Noted - it's actually about investing in developing new technology not about buying tech. Chapter 6 includes data on energy technology costs	Takarina	Noverita	Universitas Indonesia	Indonesia
22385	64	21	64	22	The last sentence does not seem to be complete or correctly written, please check this part to make sure.	Accepted - text revised -We have split this sentence into 2 sentences for clarity	Zhao	Xiusheng	Tsinghua University	China
39653	64	24	64	34	It should be noted that this type of energy transition described only indicates a switch from a dominant energy carrier to another, while the total use of these energy carriers has continued to increase on a global scale. Therefore, the transition required to solve climate change are of a somewhat different nature, where the use of fossil fuels needs to be decreased/phased out. Interesting paper on energy transition field/concept: Araújo, K., 2014. The emerging field of energy transitions: Progress, challenges, and opportunities. Energy Research & Social Science 1, 112–121. https://doi.org/10.1016/j.erss.2014.03.002	Accepted, the reference is noted and is included	Davidsson Kurland	Simon	Chalmers University of Technology	Sweden
26191	64	24	66	11	this section (263 on energy transitions) has significant overlaps with chapt 6 section 6.7 energy system transition in the near and medium future. Imprtant to consider coordination between chap 2 and 6 at least for this section	Accepted - text revised -We include cross references to ch6 and have coordinated overlap with them.	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)

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44795	65	5	65	6	I suggest the addition of the following reference, regarding the fast energy transition in Sweden. Qvist, S.A., and B.W. Brook, 2015: Potential for Worldwide Displacement of Fossil-Fuel Electricity by Nuclear Energy in Three Decades Based on Extrapolation of Regional Deployment Data. PLoS ONE 10(5): e0124074, https://doi.org/10.1371/journal.pone.0124074.	Accepted, the reference is noted and is included	Westlén	Daniel	Liberal party Swedish parliament	Sweden
15981	65	7	65	8	Comment to sentence: "including: lighting in Sweden, cook-stoves in China, liquefied petroleum gas stoves in Indonesia, ethanol vehicles…." Please update with recent example like electric car, biofuel etc.	Accepted - text revised - we now mention adoption of Evs in Norway	Takarina	Noverita	Universitas Indonesia	Indonesia
44751	65	10	65	10	Consider using the Swedish nuclear programme as an example of a fast energy transition. It was even faster than the French, though the French nuclear programme was also fast.	Accepted - text revised - we now include the Swedish nuclear example and a reference to it.	Westlén	Daniel	Liberal party Swedish parliament	Sweden
18407	65	6	65	11	Which study? Reference is necessary.	Notes - ref is included.	Shiyan	Chang	Tsinghua University	China
15753	65	6	65	17	The case of Uruguay, which according to The Guardian, in only 10 years "Uruguay makes dramatic shift to nearly 95% electricity from clean energy", might also be included. https://www.theguardian.com/environment/2015/dec/03/uruguay-makes-dramatic-shift-to-nearly-95-clean-energy Business insider reports the same story: https://www.businessinsider.com/uruguay-made-a-dramatic-shift-towards-clean-energy-2015-12	Accepted, will now mention Uruguay	FRACASSI	EDUARDO PEDRO	ITBA Instituto Tecnologico de Buenos Aires	Argentina
39655	65	31	66	9	Others claim that there are physical constraints to how fast industrial capacity can and should grow. See eg: Kramer, G.J., Haigh, M., 2009. No quick switch to low-carbon energy. Nature 462, 568–569. https://doi.org/10.1038/462568a and Davidsson, S., Grandell, L., Wachtmeister, H., Höök, M., 2014. Growth curves and sustained commissioning modelling of renewable energy: Investigating resource constraints for wind energy. Energy Policy 73, 767–776. https://doi.org/10.1016/j.enpol.2014.05.003	Accepted - text revised - We now include both references.	Davidsson Kurland	Simon	Chalmers University of Technology	Sweden
39651	65	1			Figure 2.23 is confusing. The total energy on the right axis should have its own figure, preferably with the same division between energy resources to highlight that although the dominating resources may have switched, the absolut values have kept increasing.	Noted. We recreated these data as 2 figures but given space constraints, we decided to use a single figure but with redesign to make it clearer.	Davidsson Kurland	Simon	Chalmers University of Technology	Sweden
15983	66	9	66	9	In sentence: "Table 2.44 summarizes the….Is it the Table 2.44 or 2.4?	Accepted, changed to correct Table number.	Takarina	Noverita	Universitas Indonesia	Indonesia
15985	66	10	66	10	Table 2.4 is it central or align right, check the format of table	Accepted. We fixed alignment to fit with style guide and have considerably updated the table.	Takarina	Noverita	Universitas Indonesia	Indonesia
45135	66	10	66	11	The phrase “likelihood of technological breakthroughs” may be supported with phrases similar to “innovative business/collaborative models,” which may include but not be limited by principles that relate to the sharing economy and new business and collaboration models that support the diffusion of renewable energy more dynamically.	Accepted - text revised - We have revised table completely	Kilkis	Siir	The Scientific and Technological Research Council of Turkey	Turkey
2323	66	11	66	11	I disagree with the fact that economic growth is an argument for expecting fast energy transition, the recent example of China contradicts it. "economic growth" could be replaced with "sustainable economy" for example. The same argument applies for "globalization" which could be replaced with "investment reorientation" for example.	Rejected. This argument has appeared in the peer reviewed literature and we feel it is in important perspective to include.	Martinerie	Patricia	CNRS	France
15987	66	14	66	14	In sentence: "They can improve in efficiency, performance…." It should be "They can improve efficiency, performance….	Rejected. We meant the text as is.	Takarina	Noverita	Universitas Indonesia	Indonesia
15989	66	22	67	14	What are the relevancy of explaining the Type-1 to Type-4 technology; it sounds too theoritical.	Accepted - text revised - we have simplified to just 2 easy-to-explain categories, large and small.	Takarina	Noverita	Universitas Indonesia	Indonesia
28345	66	10			It is mentioned in the text "Table 2.44 but the caption of Table is 2.4";	Accepted. Fixed typo	Chan	Hoy Yen	ASEAN Centre for Energy	Malaysia
28347	66	10			The table intends to show the arguments of slow and fast transitions, however, they are not easy to understand. E.g. incumbent should be clarified that it refers to fossil fuels? Also, the points between "slow" and "fast" are not comparative one-to-one, so suggest to use bullet or number for each point	Accepted - table has been fully revised to make it more clear	Chan	Hoy Yen	ASEAN Centre for Energy	Malaysia
20507	67	7	67	13	CCU is entirely missing in this section, while system understanding has grown substantially that zero GHG emission systems are strongly based on CCU, in particular DACCU and Power-to-X technologies. This is described in Fasihi et al. (https://www.sciencedirect.com/science/article/pii/S0959652619307772 ; https://www.sciencedirect.com/science/article/pii/S1876610216310761), Horvath et al. (https://www.sciencedirect.com/science/article/pii/S0196890418302152), Breyer et al. (https://onlinelibrary.wiley.com/doi/full/10.1002/pip.3114), Khalili et al. (https://www.mdpi.com/1996-1073/12/20/3870), Osorio-Avarena et al. (https://journals.aau.dk/index.php/sepm/article/view/3385), and last but not least in a major report by Ram et al. (http://energywatchgroup.org/wp-content/uploads/EWG_LUT_100RE_All_Sectors_Global_Report_2019.pdf)	Rejected - outside of scope of this chapter	Breyer	Christian	LUT University	Finland

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45407	67	7	67	13	Refers to nuclear as large and built on-site, hat about factory-fabricated small-modular reactors and microreactors (<10MW)?	Accept. We now inlcude small nuclear	Lovering	Jessica	Carnegie Mellon University	United States of America
22387	67	13	67	13	It seems that a linking verb "are" is missing between "plants" and "apt", please check again to make sure.	Accept revision "are apt"	Zhao	Xiusheng	Tsinghua University	China
18359	67	14	67	21	Figure 2.24 is good to explain the range of technologies. Also it is important to highlight the role of general purpose technology as enabler of deep emisssion cut. More should be discussed here how general purpose technology contributes to massive emission cut with examples including material technoologies.	Accepted - We now include cross-references to other chapters 6, 17 and refer to examples on sunbio, ai, creutzig work	Hombu	Kazuhiko	Graduate School of Public Policy, The University of Tokyo	Japan
15991	67	24	67	24	Comment to sentence: "Among the most notable are solar photovoltaics, wind power…. The photovoltaic is not a good example since it also can cause climate change. See Potential impact of climate change on solar resource in Africa for photovoltaic energy	Rejected. Chapter 6 includes LCA analysis and supports the assessment that PV cannot cause climate change.	Takarina	Noverita	Universitas Indonesia	Indonesia
8803	67	29	67	32	It would be important to highlight that the future cost reduction potential of solar PV may not be as high as what it was experienced in the past decade whereas a much higher reduction could be expected for battery systems. For battery systems, it is also important to distinguish between the cost reduction potential of its different technologies (li-ion, lead acid, flow-based, high-temp etc) as they are varying stages of deployment.	Rejected.. speculative, we do not think we need to make claims about the relative expected cost change in PV and batteries	Değer	Saygın	SHURA Energy Transition Center	Turkey
20509	67	23	67	34	latest cost insights and projections for solar PV costs should be added for this section, according to Vartiainen et al. (https://onlinelibrary.wiley.com/doi/full/10.1002/pip.3189) and Haegel et al. (https://science.sciencemag.org/content/364/6443/836) also highlight the further potential	Accepted - We have made sure our data in this section are up to date; as much as possible that means through 2019.	Breyer	Christian	LUT University	Finland
26193	67	22	69	27	Oiverlaps with chap 6 page 20-21 on the costs. Coordination and cross reading to be considered between the 2 chapters	Accepted. We have coordinated with chapt 6. Here our focus is on the change not on the level of costs.	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
36473	67	21	72	5	Would be useful to have a overiew (including a paragraph) as table or figure of recent Type I – IV technologies of the last 10 -20 years and eventually including those which are currently under development. One could then add the following section on PV as an example. Followed then by a chapter on successful/non-successful technologies (which would include e.g. Fig. 2.30) and the reasons to succeed by reducing costs is one of them. I am not convinced that section on 'sources on cost reduction' is useful nor the structure of the sections as their content is not well organized yet. It currently includes a mixture of emerging technoligies since the 20th century, developemtn of solar Pvs in diffiernt coutries, outputs of IAMs for CSS(?) and solar Pvs and then historical production rates of solar PV companies ending with DACCS/BECCS scenarios	Accepted. We are adding some new material to address this in SOD. We have also dropped the 4 types focusing on small vs large.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
30843	68	1	68	1	Why are these figures so small, and why is the x-axis so hard to read and so largely empty? Also, batteries where invented 100s of years ago, why does the price only go back a couple of decades? The y-axes are all in different units, so for once it's actually unhelpful to put the same numbers on them or people will read directly across and try to compare W with MWh.	Accepted. We have adjusted the fonts and format of the figure. Here we are just pointing out the slopes so it is not misleading	Lamboll	Robin	Imperial College	United Kingdom (of Great Britain and Northern Ireland)
30845	68	8	68	8	It's unclear what probabilities/ranges the blue error bars indicate	Accepted. we clarify the range "Blue area shows the range between the 10th and 90th percentile in each year. "	Lamboll	Robin	Imperial College	United Kingdom (of Great Britain and Northern Ireland)
30847	68	8	68	8	The sentence is mangled. It's unclear who has criticised it in this way, and whether that criticism has any merit.	Rejected. It is unclear to what sentence the reviewer is referring	Lamboll	Robin	Imperial College	United Kingdom (of Great Britain and Northern Ireland)
36471	68	10	68	10	Add reference years 2010 – 2018 into figure or caption	Accepted. Figure has been revised so x axis includes years	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
26195	68	11	69	70	Line 4. This section is too long.	Accpeted - we have moved almost all of this material to Chapter 16 where there is more space for this detail.	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
5199	69	11	69	20	The numbers after references are not clear.	Accpeted - we have moved almost all of this material to Chapter 16 where there is more space for this detail.	Alataş	Sedat	Aydın Adnan Menderes University	Turkey
15993	69	25	69	25	Based on Fig. 2.27 & 2.28 it is better to explain how the use of PV can significantly contribute to the reduction of emissions.	Accpeted - we have moved almost all of this material to Chapter 16 where there is more space for this detail.	Takarina	Noverita	Universitas Indonesia	Indonesia
15995	70	6	70	7	Comment to sentence: "not just on improvement in technologies but widespread adoption of them…" I think the transition & adoption of technology was determined by policy, price rather than single factor.	Rejected. We do not make claims about what factors cause widepsread adoption. See ch16 for detail on that topic.	Takarina	Noverita	Universitas Indonesia	Indonesia

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26197	70	6	70	7	Energy systems transition is much more complex and there are sharp variations according to regions and countries. Among others countries particularly many developing countries with signifcant fossil fuel resources will be more encline to slow down the speed of the transition	Accepted. We do not go into detail on the complexity in this short section; it is covered in chapter 16.	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
2589	70	15	70	15	Reference is made here to CFL, compact fluorescent Lighting, however solid-state lighting (SSL) using light emitting diodes (LEDs) is far more efficient and widespread. Around 20% of the world's energy is used for lighting; since LEDs are 5x more efficient (including step-down voltage transformers) this could be reduced to around 4% of electricity consumption. There is discussion in Chapter 5 of this report.	Rejected - beyond scope of chapter. We just mention here that CFLs have diffused rapidly; we do not yet have sufficient empirical data in the peer reviewed lit on LEDs, even if they are more efficient. See chapters on demand (ch 5) and innovation (ch16).	Czerniak	Michael	Atlas Copco - Edwards	United Kingdom (of Great Britain and Northern Ireland)
26199	70	15	70	15	Please explain what do you mean by nuclear CFL. The two are completely different (see your fig 2.30)	Accepted. We have added commas to make clear this is a list.	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
34065	70	15	70	15	"nuclear power compact fluorescent lighting (CFLs)?"	Accepted. added commas to make clear this is a list.	BONDUELLE	Antoine	Climate Action Network France	France
35363	70	15	70	15	"nuclear power compact fluorescent lighting (CFLs)" : it seems the words "nuclear power" were added in the middle of a sentence	Accepted. added commas to make clear this is a list.	MIJEON	Charlotte	Réseau "Sortir du nucléaire" - member of the French Réseau Action Climat	France
45921	70	17	70	19	The original figure from Wilson 2013 has a legend that indicates that each curve relates to a different region and study. Without this legend, the figure can easily become misleading. A minimum would be to provide the complete information. The current figure is NOT appropriate to show adoption or share of those technologies at the global scale, or in any region : instead, each curve relates to a specific region and study, and thus cannot be compared to others in terms of specific timing or magnitude; it only shows at what rate each technology has been adopted in a study region (that is not the same as for other curves). Either the context and meaning of this figure has to be explained in much clearer, complete and precise terms, or it has to be replaced by something that involves a common study area.	Accepted. We will explain this figure in more detail if we decide to keep it for the SOD.	Marbaix	Philippe	UCLouvain, Belgium	Belgium
31945	71	2	71	6	There is a reason for this: the IAMs are being driven with a policy goal that requires FFI CO2 emissions to reach net zero, given the limited offset potential of NbCS. Net zero FFI CO2 emissions means 100% net sequestration (combined CCS, BECCS and DAC). Reaching that by mid-century requires a rapid scale-up of CCS. This is not the case for any of the other technologies listed. This reason should be mentioned, rather than the issue being left hanging.	Accepted - we have updated the section on model results - but do not have space here to identify reasons that IAMS prefer CCS or clarigy debates about which technoloigies are most important to reach net zero emissions.	Allen	Myles	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
31955	71	2	71	6	There is a reason for this: the IAMs are being driven with a policy goal that requires FFI CO2 emissions to reach net zero, given the limited offset potential of NbCS. Net zero FFI CO2 emissions means 100% net sequestration (combined CCS, BECCS and DAC). Reaching that by mid-century requires a rapid scale-up of CCS. This is not the case for any of the other technologies listed. This reason should be mentioned, rather than the issue being left hanging (it is not clear at present whether the authors consider these CCS scale-up rates as credible or not).	Accepted - we have updated the section on model results - but do not have space here to identify reasons that IAMS prefer CCS or clarigy debates about which technoloigies are most important to reach net zero emissions.	Allen	Myles	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
20511	71	1	71	10	it is highly questionable to see high fossil CCS growth rates in IAMs, while solar PV is already today the least cost source for electricity in most regions in the world - a central reason may be wrong PV cost assumptions in IAMs, which is now documented by Krey et al. (https://www.sciencedirect.com/science/article/pii/S0360544218325039) with about 1150 USD/kWp PV investment cost assumptions in 2050 in practically all IAMs, while the real cost in the year 2020 are HALF of that, as shown by Vartiainen et al. (https://onlinelibrary.wiley.com/doi/full/10.1002/pip.3189) - AND further PV cost reduction in the years from 2020 to 2050 will come on top, so that in 2050 one can assume wrong PV cost in IAMs by a factor of 4. This requires a major disclaimer on substantially distorted IAM results. Even worse, this leads to a block of CCU and Power-to-X since such low/zero-carbon solutions require low-cost electricity, which cannot be found in IAMs with wrong PV cost. This requires a major disclaimer.	Accepted. This is a good point but is beyond the scope of detail we are able to provide in a short section. We have substantially expanded our discussion of empirical growth rates and models and do now include both these reference.	Breyer	Christian	LUT University	Finland
20513	71	14	71	19	a fast DACCS phase-in scenario is discussed in Breyer et al. (https://www.cell.com/joule/fulltext/S2542-4351(19)30413-1), in analogy to the phase-in of solar PV, this reference would further provide substance this section	Accepted. We now include this reference in our comparison of PV and DACCS.	Breyer	Christian	LUT University	Finland

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
42391	71	25	71	25	"For negative emissions technologies like, DACCS, the key scale up and technology adoption period is 25 between 2030 and 2050 (Figure 2.34)(Nemet et al. 2018). In that case we see a central value of about 26 6 GT of CO2 removal per year, or about 15% of current CO2 emissions by 2050" Scale up rates can be considerably flatened by designing regulation to srart scale up earlier, as the technology is ready. This has been discussd by some authors. e.g. https://doi.org/10.3389/fclim.2019.00010 ...Various climate scenarios predict negative emissions at gigaton scale by mid-century. What does this mean for CDR scale-up pathways? An example: to reach a mean pathway of around 6 gigatons of CDR by 2050 as calculated in a recent comprehensive review of the relevant literature (Nemet et al., 2018), from 2019 onwards, CDR would require an annual growth rate of over 55%. Delaying scale-up to 2025 would already require a sustained growth of 80% per year, whilst scale-up starting in 2030 when most CDR policies are currently recommended to set in, would require roughly a yearly doubling of CDR capacity. Scales like these are hard to achieve and from a risk perspective, it would therefore be vital to start scaling earlier.	Accepted. We have removed discussion of DAC scale-up specifically due to space constriants on this section.	Beuttler	Christoph	Climeworks AG, Risk Dialogue Foundation	Switzerland
44483	71	24	71	26	Not sure if one can say that the key period 'is' 2030-2050, and then also use the exact 6 Gt from Nemet at al. 2018. I guess this is not so much about the exact numbers (if it is, use the numbers from the AR6 scenario database) but just an illustrative example to highlight the challenges. Maybe better to explicitly say so, to avoid that readers are confused by the 6 Gt (not the least since it's unclear what the underlying pathways are, incl. the intended temperature outcome)	Accepted. We have removed discussion of DAC scale-up specifically due to space constriants on this section.	Geden	Oliver	German Institute for International and Security Affairs	Germany
9581	71	30	72	2	The statement about the need for addition of plants (misleadingly) implies that facilities need to be built from the ground – but the world could start by implementing CCS at the remaining 200+ ethanol plants in the USA (Sanchez et al. 2018: Near-term deployment of carbon capture and sequestration from biorefineries in the United States, PNAS) and at the remaining ethanol plants in the rest of the world. Ethanol fermentation produces a near-pure stream of biogenic CO2 and is the most commercially-attractive BECCS application (Global CCS Institute 2019: Bioenergy and carbon capture and storage, available online). It should also be mentioned (here or elsewhere) that more than 60% of the CO2 captured via BECCS in the IEA's 2-degree scenario (2DS) is associated with biofuels production (IEA 2017: Technology Roadmap - Delivering Sustainable Bioenergy, available online).	Accepted. We have removed discussion of DAC scale-up specifically due to space constriants on this section.	Kløverpris	Jesper	Novozymes	Denmark
10359	71	14	72	4	This brief section could be expanded and harmonised with chapter 3 since a consistent treatment of the feasibility of NET upscaling is a key issue. As it stands this discussion seems to short to do the issue justice. Also note the discussion of NETs in chapter 12, and governance issues in chapter 14 - please coordinate with those chapters,	Accepted. We have removed discussion of DAC scale-up specifically due to space constriants on this section.	Reisinger	Andy	NZAGRC	New Zealand
5201	72	12	72	12	The sentence should be corrected as "including funding and performing research"	Accepted. We have removed discussion of policy from this section. Section 2.9 now discusses policy. Also see chapters 13 and 16 for discussions of policy related to technological change.	Alataş	Sedat	Aydın Adnan Menderes University	Turkey
15997	72	22	72	24	Comment to sentence: "Governments can also stimulate technological change indirectly by creating or enlarging markets…" The other stimulus that can be added including tax free for importing raw materials, technology transfer etc.	Accepted. We have removed discussion of policy from this section. Section 2.9 now discusses policy. Also see chapters 13 and 16 for discussions of policy related to technological change.	Takarina	Noverita	Universitas Indonesia	Indonesia
14271	72	24	72	24	Addtion: "...public procurement (e.g. the most recent bill A08617 suggested by the New York State for public procurement on CCU concrete)..."	Accepted. We have removed discussion of policy from this section. Section 2.9 now discusses policy. Also see chapters 13 and 16 for discussions of policy related to technological change.	Perimenis	Anastasios	CO2 Value Europe (Association) - CCU Offiver	Belgium
28205	72	22	72	27	In the case of Evs it ius important to note the EU CO2 targets (https://theicct.org/sites/default/files/publications/ICCT_CO2_emissions_pv_EU_2018_20190806.pdf) that force car manufacturers to scale up the roll out of Evs. As important is that regulatory action by a limited number of geographical entities (China and EU) have the potential to influence or shape GLOBAL technology development and roll out.	Accepted. We have removed discussion of policy from this section. Section 2.9 now discusses policy. Also see chapters 13 and 16 for discussions of policy related to technological change.	Huizenga	Cornie	CESG	Germany

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
45137	74	1	74	9	The examples that are given for "adoption of technologies with co-benefits" can be more illustrative with the inclusion of the public health benefits and job opportunities that are created with renewable energy. References include but are not limited to 53 towns and cities in <https://doi.org/10.1016/j.scs.2018.06.031> as well as the combination of renewable energy and energy efficiency as given in “the impact on air quality of energy saving measures in the major cities signatories of the Covenant of Mayors initiative” in <https://doi.org/10.1016/j.envint.2018.06.001> and others.	Accepted. We have removed discussion of policy from this section. Section 2.9 now discusses policy. Also see chapters 13 and 16 for discussions of policy related to technological change.	Kilkis	Siir	The Scientific and Technological Research Council of Turkey	Turkey
5045	74	36	74	37	In the 3rd column, "Broad social consensus", it reads "difficult to predict public acceptance". This is not true. I was wondering the authors read the papers on the list. Examples are awful as well. Why "WW2, THe Marshall plan, the Cold War the 1970 Oil Crisis? Those are not on the papers on the list.	Accepted. We have removed discussion of policy from this section. Section 2.9 now discusses policy. Also see chapters 13 and 16 for discussions of policy related to technological change.	Aoyagi	Midori	National Instituute for Environmental Studies	Japan
44485	74	37	74	37	Policy alignment: a) clear mid-/long-term targets/visions (see literature on targets, e.g. https://doi.org/10.1016/j.enpol.2012.12.057 and https://www.nature.com/articles/ngeo2699); b) What slows down: add path dependencies in continued use of instruments (see literature on 'instrument constituencies', e.g. https://onlinelibrary.wiley.com/doi/abs/10.1111/gove.12179) and status quo orientation of senior public officials (see https://onlinelibrary.wiley.com/doi/abs/10.1002/wcc.305)	Accepted. We have removed discussion of policy from this section. Section 2.9 now discusses policy. Also see chapters 13 and 16 for discussions of policy related to technological change.	Geden	Oliver	German Institute for International and Security Affairs	Germany
44487	74	37	74	37	Broad social consensus: in general, maybe expand to "political consensus", because this highly affects public acceptance (see Dan Kahan's work on 'politically motivated reasoning', e.g. https://onlinelibrary.wiley.com/doi/abs/10.1002/9781118900772.etrds0417)	Accepted. We have removed discussion of policy from this section. Section 2.9 now discusses policy. Also see chapters 13 and 16 for discussions of policy related to technological change.	Geden	Oliver	German Institute for International and Security Affairs	Germany
36335	74	1	84	16	This is a very interesting section. However it only captured the situation of industrialised and emerging economy. The lifestyle of indigenous people, local communities of many parts of the world, traditional pratices and way of living in many developing countries are overlooked.	Accepted - we found limited mitigation related research for these communities but will effort to add more. We improved adding more references and literature from developing countries in this section.	Sokona	Youba	South Centre	Switzerland
24081	75	1	75	1	This section should be named "consumption patterns and behaviour" to better reflect the fact that it is not only about individual choices, but also about collective consumption patterns	Rejected - The main focus of the chapter is behavioral choices. In subsection 2.7.2, the term consumption pattern appears when it is relevant.	Lecocq	Noé	Inter-Environnement Wallonie	Belgium
26201	75	4	75	7	This sentence is not clear. GDP is the aggregated added alue of production of goods and services. It is not calculated based on the households consumption. Reformulation may help clarify the concept	Accepted, we have changed this sentence.	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
18067	75	16	75	18	In my view, describing demand for products and services as being dependent only on "choice" (meaning decisions of individuals) as a narrow view prevalent in economics, but not reflecting large literatures in social sciences acknowledging that indivdual decisions to buy a specific product are usually driven to a large extent by the social embeddedness of an individual agent. By adopting the economic language hinting at "rational choice" as one specific paradigm of understanding such decisions, this graph fails to acknowledge the need to understand such decisions in a much broader context than only in an economic rational choice context. E.g. practice theory assumes that actors adopt "practices" depending on their embeddedness in social institutions, also depending on the options they have as determined e.g. by the availability of certain infrastructures,etc. I hence propose to revise the figure so as to not exclude these many different perspectives that are hugely important also in Chapter 5. Framing this as a "choice" problem also contradicts key findings in Chapter 5, lines 26-39	Accepted. The Figure was deleted.	Haberl	Helmut	Institute of Social Ecology, University of Natural Resources and Life Sciences, Vienna	Austria
5203	75	26	75	26	The citation style is not consistent. This should be corrected as "Hubacek et al. 2017"	Accepted, the text was edited.	Alataş	Sedat	Aydın Adnan Menderes University	Turkey
26205	75	20	78	20	Almost all examples are on China and US. Not a single example on Africa or Latin America which is very dffierent	Accepted, will have added some more literature on Latin American and developing countries but could not find much on Africa.	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
5043	75	1	84	16	This section is titled "2.7 Behavioral Choices and Lifestyles". The description of the current situation of lifestyles and public behavior is too simple and those are written in other chapters. Especially those issues are dealt with in chapter 5 more precisely and deeper. For the sake of the limited number of pages, one idea is that deleting this part and cite Chapter 5.	Accepted. Empirical information was included in this section and chapter 5 was also cited in the text.	Aoyagi	Midori	National Instituute for Environmental Studies	Japan

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
10361	75	1			Section 2.7 seems to duplicate some material already covered in sections 2.3 and 2.4, and obviously chapter 5. Please harmonise the treatment of behavioural issue at least within chapter 2, but also coordinate with chapter 5 to be clear what needs to be here in this chapter and what is in chapter 5 (which ought to be the central hub for behavioural perspectives - there doesn't seem to be a clear scope and delineation for the discussion here. Also far too much discursive literature review but no clear assessment or conclusions). This is understandable for the FOD but please ensure this gets clarified with chapter 5. Also many of the drivers covered in pages 78-83 covers material that already has been covered in section 2.4. Please ensure this is done only once, not repetitively.	Accepted. Taken into account - Harmonization was done with section 2.4 and redundancy was removed. Moreover, a reference to chapter 5 for more comprehensive discussion was added.	Reisinger	Andy	NZAGRC	New Zealand
2325	76	5	76	5	I find Figure 2.36 much less clear than the famous Figure 4 in https://www-cdn.oxfam.org/s3fs-public/file_attachments/mb-extreme-carbon-inequality-021215-en.pdf illustrating the same kind of data. The graphical concept should be reworked.	Rejecteded. Figure was revised. Our figure is based on about 100 countries representing more than 90% of the global population.	Martinerie	Patricia	CNRS	France
26203	76	4	76	6	Difficult to read this figure. Perhaps 2 figures instead of 1 or different presentation	Accepted, the figure has been changed and the inset deleted.	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
22389	76	14	76	16	Possible reasons for a fairly uneven distribution of carbon prints also include the factor of “natural conditions” which should not be ignored at this point, for example, people living in extremely cold regions or very hot areas have to consume larger amount of energy for household/office heating in winter, and cooling in summer than those living in places with relatively temperate or mild climates.	Accepted, we have added this point.	Zhao	Xiusheng	Tsinghua University	China
15999	76	23	76	24	In sentence: "the largest contribution to the household carbon footprint is from transportation, housing, and food....." What doesn’t mean with food? Can you elaborate this?	Accepted - The sentence was clarified in the text.	Takarina	Noverita	Universitas Indonesia	Indonesia
24253	76	5			It is better to add the title of horizontal and vertical coordinates for the inset in Figure 2.36.	Rejected. We have removed the figure.	Zhifu	Mi	University College London	United Kingdom (of Great Britain and Northern Ireland)
6987	76	6			Does the figure refer to Carbon footprints based on production or consumption?	Editorial - Clarified in the text.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
28349	76	6			Not sure how useful this figure is, it is not easy to read. Suggest to delete if not too significantly important	Accepted. The figure has been revised.	Chan	Hoy Yen	ASEAN Centre for Energy	Malaysia
25851	77	2	77	10	In this particular section, it is indeed relevant to compare the different emission patterns. However, the entire point is lost when the categorical classification of the sources is not directly comparable. In other words, the concept of “meat” from the US is not comparable to the concept of “food” from Japan. In order to improve this section, it would be necessary to homogenize the concepts to allow direct comparisons. Alternatively, it would clearer to present this data with a figure rather than text.	Rejecteded. Since different sources provide different classifications, it is not possible to have one Figure for comparison. Therefore, the textual presentation is the best option.	Hoyos-Santillan	Jorge	University of Magallanes	Chile
16001	77	11	77	18	Please elaborate this section by providing examples from comparable countries to China like India for example.	Accepted - Literature for other countries were included.	Takarina	Noverita	Universitas Indonesia	Indonesia
16003	77	16	77	18	Comment to sentence: "In comparison, Indonesian rural households has a large....." How about Indonesia urban household for comparison?	Accepted - A reference to the share of transport in Urban emissions in Indonesia was included.	Takarina	Noverita	Universitas Indonesia	Indonesia
22391	77	27	77	27	more diverse energy inputs, such as biomass, biogas, solar, wind, small hydro and geothermal in addition to coal where still possible. (particularly for the case of China's rural areas)	Accepted. Text has been modified to include other energy inputs in rural areas.	Zhao	Xiusheng	Tsinghua University	China
18379	77	29	77	30	The situation will not happen in China. In China, the transport emissions of rural households is lower than the urban households, because the rural travel is mostly based on public buses or motorcycles, little of rural households owning private cars in China. In recent years, this situation will slightly change, but still a small number of rural households buy cars in China, and people lives in cities like travel by private car in China.	Accepted and caveat added.	Guo	Jie	China Academy of Transportation Sciences	China
18377	77	25	77	36	A case study can be added here. It is very different from Norway and the Netherlands, the population density and emission intensity are large in China, so it's typical as a case.	Accepted - A reference in China was added to explain its case.	Guo	Jie	China Academy of Transportation Sciences	China
16005	77	19	78	16	I think the relation of emission with lifesyle demography (sex, age, population) should be visualized with graph for better understanding.	Accepted. More Empirical evidence and graphs were included in text to the extent possible. Also, age factor was added as a separate factor and sex impact was also included in the text under 2.6.2.	Takarina	Noverita	Universitas Indonesia	Indonesia
36475	77	19	78	21	Could be useful to have some/all of these comparative statistics given in this section as compact informative diagrams as these are really good examples on the large differences between countries/gender/rural-urban	Accepted - Empirical evidence and Figures to the extent possible have been included in this section.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
6989	77	30			rural households have a higher emissions related to food consumption or transportation relative to urban ones or absolute?	Accepted. This is in relative terms.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
6991	77	39			what happens to the correlation after the threshold is reached? Does the correlation turn negative, is it zero, or does it get stronger?	Rejected. The section has been shortened and thus this has been deleted.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
22393	78	17	78	17	The first letter of "Internet" should be in lower case	Editorial - Text has been corrected.	Zhao	Xiusheng	Tsinghua University	China
16007	78	17	78	20	Please provide the countries where internet-emission relation is derived, the Internet change to internet.	Rejected. It is not appropriate to provide the full list of countries in the text. It is clearly stated that the study focused on OECD countries.	Takarina	Noverita	Universitas Indonesia	Indonesia
24087	78	22	79	4	This section could mention the behavioural and consumption patterns changes in link with the crisis situation from coronavirus outbreak, which has lead to measures that limited travel in several countries, with a direct impact on emissions (see : https://www.carbonbrief.org/analysis-coronavirus-has-temporarily-reduced-chinas-co2-emissions-by-a-quarter). Propably much more detailled analysis of the impact of consumption patterns changes related to coronavirus outbreak will be available in the coming months, and could be reflected with due balance (co-benefits and adverse side effects).	Accepted. A box on the impact of COVID-19 on behavioral choices will be included in chapter 5. A cross-reference has been added in chapter 2.	Lecocq	Noé	Inter-Environnement Wallonie	Belgium
16009	78	23	80	48	This section Factors affecting household consumption patterns and behavioural choices is too theoritical and should be elaborated with the quantity how those factors explicitly affect the emissions in numbers,	Accepted- Empirical evidence have been included in the section.	Takarina	Noverita	Universitas Indonesia	Indonesia
24085	78	22	83	5	In the list of "Factors affecting household consumption patterns and behavioural choices", income and affluence should be more clearly discussed because it is an important driver. As stated in Chap. 2 p.51 line 25 : "With respect to per-capita CBE, income is the most important driver of household carbon footprints in Europe (medium-robust evidence, high agreement) (Ivanova et al. 2016), (Christis et al. 2019), (Wang et al. 2016)."	Accepted - Income is discussed from the starting point of this section as the most important predictor of behaviour and lifestyle patterns. Aside from assessing why income predicts behaviour and lifestyle, we added a Figure that compares carbon footprints of countries attending to income category.	Lecocq	Noé	Inter-Environnement Wallonie	Belgium
38147	78	22	84	17	It will be good to include figures to show the impact of each of the influencing factors indentifying in this section on lifestyles and behvior change, see : https://www.carbone4.com/wp-content/uploads/2019/06/Publication-Carbone-4-Faire-sa-part-pouvoir-responsabilite-climat.pdf	Accepted. Empirical evidence has been included in the text and Figures were included, to the extent possible. The reference cited in the comment seem to be interesting but it is considered grey literature as it is not a peer reviewed paper.	Saheb	Yamina	OpenExp, Ecole des Mines de Paris	France
24255	78	6			"(Han,Xu and Han,2015)" should be revised as "(Xu and Han, 2017)".	Editorial - text has been corrected.	Zhifu	Mi	University College London	United Kingdom (of Great Britain and Northern Ireland)
6993	79	1	79	4	Here, the world bank reports on "State and trends of carbon pricing" could be cited since they provide a good cross-country picture about carbon pricing schemes (for 2019: https://openknowledge.worldbank.org/handle/10986/31755)	THIS COMMENT was transferred to THE POLICY SECTION 2.8 and will NO longer be in 2.6).	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
2327	79	28	80	6	The short section on environmental knowledge does not mention its evolution (e.g. Fridays for Future movment) or the (potential) role of education. Are there scientific studies assessing that?	Accepted. Additional text on education has been included. However, did not include Fridays for the Future since no assessment of their impact was readiliy available.	Martinerie	Patricia	CNRS	France
30927	80	7	80	18	I would put more care on carbon labeling of products. The paragraph is poorly written and it does not explain very well. I agree with the conclusion that carbon labeling schemes should be introduced carefully but i don't agree on the fact that consumers are not interested. Basically the interest of consumer is very different from country to country. besides this the similarity proposed between the certification of organic food and carbon neutral food is dangerous and misleading	Accepted. The sentence which suggests similarity between organic food and other carbon labelled products has been deleted.	Bartocci	Pietro	University of Perugia	Italy
11729	81	1	81	2	"Improvements in the efficiency of time or resource use are diminished by rebound effects which have been shown to reduce emissions savings by 20-40% on average (Gillingham et al. 2015)." Comment: this ignores the growing number of studies which are suggesting that total, economy-wide rebound may be much larger, over 50%. For example: Bruns & Stern (2019) whcih you already reference elsewhere. also consider to include Saunders, H. D. (2015). Recent Evidence for Large Rebound: Elucidating the Drivers and their Implications for Climate Change Models. The Energy Journal, 36(1), 23–48.	Accepted - Saunders (2015) has been referenced and the text has been ammended to highlight that higer rebound effects are possible.	Brockway	Paul	University of Leeds	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
15755	81	33	81	40	Inequality may be the typical result of any economic system that produces wealth. Inequality is created because some are more successful than others at producing wealth. Some work more, others prefer to work less for different reasons. Some are brighter than others. Inequality is not good nor bad, it is just the result of meritocracy, like in the 3 little pigs story, those who "play all day" get their houses blown appart by the wolf, and those who "all he does is work all day" have houses that withstand the efforts done by the wolf to eat them. And people prefer unequal societies, acording to this article published on The Guardian https://www.theguardian.com/inequality/2017/may/04/science-inequality-why-people-prefer-unequal-societies states: "It follows, then, that if one believes that (a) people in the real world exhibit variation in effort, ability, moral deservingness and so on, and (b) a fair system takes these considerations into account, then a preference for fairness will dictate that one should prefer unequal outcomes in actual societies." So I feel that "having equal opportunities" is more useful than "equality". Communism and socialist countries have failed repeteadly, and former communist countries like Rusia and China have embraced capitalism as a way to create wealth. "It sounds counter-intuitive, so why would that be? Because if people find themselves in a situation where everyone is equal, studies suggest that many become angry or bitter if people who work hard aren't rewarded, or if slackers are over-rewarded." Taken from: https://www.bbc.com/future/article/20170706-theres-a-problem-with-the-way-we-define-inequality	Comment offers no substantive peer-reviewed literature in support of the opinions expressed, therefore none of the angles suggested can be debated as such in present report.	FRACASSI	EDUARDO PEDRO	ITBA Instituto Tecnologico de Buenos Aires	Argentina
9647	82	22	82	24	This could be further specified with an additional sentences: For most environmental goods and services (where the income elasticity of willingness to pay is less than one), willingness to pay for environmental protection is higher the more equal a society is (Drupp 2018). Drupp, M.A., Meya, J.N., Baumgärtner, S., Quaas, M.F. (2018): Economic inequality and the value of nature. Ecological Economics, 150: 340-345.	Accepted, reference and text will be considered.	Meya	Jasper	German Centre for Integrative Biodiversity Research	Germany
28207	83	44	84	3	There is increasing evidence that ride sharing and hailing services increase congestion see https://link.springer.com/article/10.1007/s11116-018-9923-2. https://www.tandfonline.com/doi/abs/10.1080/01944363.2019.1637770?journalCode=rjpa20	Accepted. It will be taken into account - references will be checked while preparing the revised paragraphs by Giovanni	Huizenga	Cornie	CESG	Germany
1071	84	13	84	13	"Measures to avoid rebound would need to be evaluated." is too strong. Rebound effects are generally economic-welfare creating so there is a tradeoff. Especially for developing countries. "Evaluated" gets partly around this, but the sentence conveys the sense that avoiding rebound is fundamentally desirable. (See also comments herein for Chapter 1.)	Accepted. It will be reviewed accordingly	Saunders	Harry	Carnegie Institution for Science	United States of America
24855	84	21	84	31	Delete "Keeping warming below … CO2 removal." to avoid redundancy	noted	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
24857	84	44	84	44	Delete "or futher contribute to lock-in"	rejected - phrase is needed	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
10363	84	20			The clarification of carbon budgets should make clear that the budget depends (amongst other things) on non-CO2 emissions - and some long-lived infrastructure also locks in those emissions. I'm unsure whether available studies have taken this into account, but at least the framing should make clear that while the carbon budget is about CO2 only, the magnitude of the available budget depends on non-CO2 emissions and some of the lock-in may also include some of those emissions.	rejected - no space. There are other places in the report where this should be clarified. The lock-in literature itself is largely on CO2 only.	Reisinger	Andy	NZAGRC	New Zealand
36477	85	15	85	15	Not sure how useful a figure on stats on amount of literature is except for to indicate current research gaps whiich is not the case in the manuscript text as here it is only use to show qualitative aspect in which fields reasearch has been done. Therefore this figure is a bit meaningless can you can consider omitting it	Rejected. Figure will not be deleted, but text and figure elaborated	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
30929	86	31	93	28	I would introduce in this paragraph some hint at coal phase out from many countries.	Noted	Bartocci	Pietro	University of Perugia	Italy
3155	87	11	87	12	The meaning of the text "the central estimate being just inside/outside the uncertainty range of recent studies" is not clear. It should be either "inside" or "outside". Does it mean near the boundary of uncertainty range? Please clarify.	Accepted - whether inside or outside depends on the study under consideration. We clarified this in the text.	LEE	Sai Ming	Hong Kong Observatory	China
10365	87				Please include error bars/uncertainties in this figure, consistent with the text.	Accepted	Reisinger	Andy	NZAGRC	New Zealand
22395	88	10	88	12	early retirement of additional fossil fuel assets would entail huge stranded costs, it could be much better to add some discussions over this point.	We have only very limited space here. This is done more comprehensively in chapter 6. But we hint in the introduction to the literature on stranded assets.	Zhao	Xiusheng	Tsinghua University	China
18409	90	32	91	2	It is recommended to use the primary information rather than secondary sources.	Noted.	Shiyan	Chang	Tsinghua University	China

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2329	90	22	91	7	This section might mention the recent "coal rebound" (https://www.iea.org/reports/coal-information-2019) to avoid sounding too optimistic in terms of trends	Accepted. We have added the reference, butdid not mention the coal rebound explicitly.	Martinerie	Patricia	CNRS	France
10367	90				Please include error bars/uncertainties in this figure, consistent with the text, and consider showing relevant carbon budgets for different temperature levels alongside those trends. This could be a potentially very useful figure if its presentation can be improved.	We have removed this figure.	Reisinger	Andy	NZAGRC	New Zealand
36483	91	16	91	16	Table 2.7 (and also the following table 2.8): Consider conversion into a bar plot as it will be easier graspable	We thought about this, but find it useful to provide the numbers.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
8805	91	15	91	17	Table 2.7 is interesting but it would be important to broaden the country scope many other coal-focused countries and if possible also update the 2017 data with more recent information as it seems a bit outdated.	Accepted. We changed the table to AR6 regional classification.	Değer	Saygın	SHURA Energy Transition Center	Turkey
26207	91	15	91	17	Please check the unit (seems very low)	Accepted and changed. It is, of coutrse, GW.	KHENNAS	SMAIL	Energy and Climate Change Consultant	United Kingdom (of Great Britain and Northern Ireland)
36479	91	20	91	24	In most of these studies indeed just potential options on changes but little on how transitions can be conducted. However some studies have been done and fine examples are given in the previous section 2.7 (e.g. 2.7.2 ff + Box 2.4)on the different types of ways how incentives can be shaped or policies could enable transformation processes. It would be useful to refer to the previous section and/or come up with some additional exemplary suggestions for transitions	Noted, but this is not the key purpose of this section.	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
10369	91	25	91	33	I'm sorry but I don't understand at all what is being presented here or the significance of it.	Accepted. We tried to provide clearer language.	Reisinger	Andy	NZAGRC	New Zealand
24859	91		91		Correct the numbering and/or reference to Table 2.7	Accepted.	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
24257	91	16			In the second row of Table 2.7, please capital the first letter of the word.	Noted	Zhifu	Mi	University College London	United Kingdom (of Great Britain and Northern Ireland)
10687	92	12	92	22	General question regarding the interpretation of this number: Are the pathways that limit global warming to 2° in 2100 still plausible? Is the target still within reach?	Noted. It is not our job to say whether they are plausible. This would involve deep value judgements. Therefore, we put the committed emissions/residual fossil fuel emissions numbers into the context of the budgets and specifc - if needed - the role and scale of CO2 removal. This should enable readers to make an informed judgements themselves.	Schenuit	Felix	University Hamburg	Germany
10689	92	12	92	22	General question regarding the interpretation of this number: Are the pathways that limit global warming to 1.5°C in 2100 still plausible? Is the target still within reach?	Noted. It is not our job to say whether they are plausible. This would involve deep value judgements. Therefore, we put the committed emissions/residual fossil fuel emissions numbers into the context of the budgets and specifc - if needed - the role and scale of CO2 removal. This should enable readers to make an informed judgements themselves.	Schenuit	Felix	University Hamburg	Germany
10691	92	12	92	22	General question regarding the interpretation of these numbers: Are the pathways that limit global warming to 2° in 2100 still plausible? Is the target still within reach?	Noted. It is not our job to say whether they are plausible. This would involve deep value judgements. Therefore, we put the committed emissions/residual fossil fuel emissions numbers into the context of the budgets and specifc - if needed - the role and scale of CO2 removal. This should enable readers to make an informed judgements themselves.	Schenuit	Felix	University Hamburg	Germany

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
10693	92	12	92	22	General question regarding the interpretation of these numbers: Are the pathways that limit global warming to 1.5°C in 2100 still plausible? Is the target still within reach?	Noted. It is not our job to say whether they are plausible. This would involve deep value judgements. Therefore, we put the committed emissions/residual fossil fuel emissions numbers into the context of the budgets and specifc - if needed - the role and scale of CO2 removal. This should enable readers to make an informed judgements themselves.	Schenuit	Felix	University Hamburg	Germany
10371	93	8	93	10	This is a key conclusion that might be worth elevating more cleatly into the ES.	Noted - and still being considered as the responses to the comments are being finalised. Most probably I would say. Thanks!	Reisinger	Andy	NZAGRC	New Zealand
38779	93	10	93	14	Which “climate goals” of the Paris Agreement? Is this referring to the temperature goals? Or something else?	Accepted. Used clearer language.	Reyes	Julian	Personal Capacity	United States of America
34365	93	16	93	16	Please add the following sentence at the end of the paragraph: "IEA scenario highlights that the use of CO2 could become a more attractive mitigation option, especially when th availability of CO2 storage is limited (REFERENCE: IEAGHG, 2019a: Putting CO2 to Use – Creating value from emissions, International Energy Agency).	Rejected. This discussion is beyond the scope of this section. Chapter 12 on cross-sectoral issues deal with such solutions.	Sapart	Célia	Université Libre de Bruxelles et Co2 Value Europe	Belgium
24861	93		93		Figure 2.41 to be revised to present scenarios that limit warming below 2°C	Rejected. These are all scenarios limiting warming well below 2°C.	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
16011	94	7	94	7	Regarding the built infrastructure, what do you think with the built green infrastructure like charging station for electric car	Noted. We have no information on this from the lines of evidence considered here. This seems to be a relevant questions for chapter 8 (urban systems) or buildings?	Takarina	Noverita	Universitas Indonesia	Indonesia
16013	94	34	94	34	In sentence: "new built infrastructure could be avoided through various infrastructure solutions….." Please mention what are various infrastructure solutions.	We have deleted this sentence	Takarina	Noverita	Universitas Indonesia	Indonesia
36481	94	5	94	40	Some of the aspect covered in this section are, although from a different point of view, already covered in section 2.7. Maybe include reference to this section?	Noted	Fetzer	Ingo	Stockholm Resilience Centre	Sweden
38149	94	4	95	13	See quantification provided in ECF Report on 2050: https://europeanclimate.org/content/uploads/2019/11/09-18-net-zero-by-2050-from-whether-to-how.pdf	Noted	Saheb	Yamina	OpenExp, Ecole des Mines de Paris	France
30849	95	1	95	1	It's unclear that this figure refers to yearly, not cumulative emissions. It's also unclear how much of it is data and how much projection (I'm assuming it's all just modelled because the lines are so straight). It's also unclear why several of the names of sections seem good ("Improvement in efficiency") when they seem to be contributing to emissions - are these sections negative emissions?	We have removed this figure.	Lamboll	Robin	Imperial College	United Kingdom (of Great Britain and Northern Ireland)
35857	95	14	95	15	This section needs more elaboration. Particularly in the developing countries, most decisions are taken considering development which includes fuel use policies, new thermal power plants, electric mobility, etc which might not be specifically for climate change but they significantly impact GHGs.	Taken into account. More literature on emission impacts of non-climate policies are reviewed.	Gupta	Himangana	Institute for the Advanced Study of Sustainability, United Nations University, Tokyo	Japan
16015	95	17	95	17	In sentence: "Environmental effectiveness of climate and other related policies…." please mention what are the other policies	Taken into account	Takarina	Noverita	Universitas Indonesia	Indonesia
38151	95	14	101	32	This section is labelled "climate and non climate policies and measures…". However, the whole section is ONLY about market instruments which is misleading. You either label the section "Market Instruments" or you include other climate and non climate policies such as regulatory ones. The latter being a better option as a policy package is needed to reduce GHG emissions	Accepted. Many non-market instruments are added in the review.	Saheb	Yamina	OpenExp, Ecole des Mines de Paris	France

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
5177	95	14	101	33	Section 2.9 examines climate and non-climate policies and measures and their impacts on emissions. As also briefly discussed in the previous cell, demand for material use might lead to a greater increase in energy use and emissions. Therefore, focusing only on energy related mitigation policies might not be sufficient for achieving sustained GHG emission reductions and increasing material efficiency provides researchers a key oppurtunity to meet carbon reduction objectives adopted by individual countries at the Paris aggrement. For example, assessment of IRP (2020) suggests that material efficiency strategieis could reduce GHG emissions by 80%-100% in 2050. Potential reductions could amount to 80-100% and 50-70% in 2050 in China and India, respectively. This is also highly important to improve innovative policies at the sectoral level. As also briefly discussed in the main text (see page 60, line 40-45), material demand as a major driver of energy consumptipn and associated emissions in the industry sector have grown much faster than population and GDP over recent decades (Krausmann et al. 2017-2018; Widenhofer et al. 2019). For example, while GDP and population grew by 150% and 40% since 1990, material growth was 250% fror cement, 240% for plastics, 210% for aluminum and 120% for steal (IEA, 2019). Therefore, I recommend to expand sections 2.9 and 2.5 with material use by emphasizing its importance for redcing GHG emissions at national and sectoral level.	Taken into account. It cannot be over emphasized that the material efficiency improvement and material demand management are one of the key area for the emission reduction. This section, however, is for the review of the emission impacts of climate and non-climate policies in the past. We need literature on the empirical evidence of emission impacts from material efficiency policies for including them in this section. Unfortunately, I couldn't find any up to now. We will try to find any literature on this issue though and will reflect what we get.	Alataş	Sedat	Aydın Adnan Menderes University	Turkey
30931	95	14	101	33	I would introduce in this paragraph some hint at coal phase out from many countries.	Taken into account. I will try to find literature on emission impacts from coal phase out policies but as of now I didn't find any emprical analysis on that.	Bartocci	Pietro	University of Perugia	Italy
24267	95	14	102	14	It would be worthy to mention that carbon pricing may be intertwined with carbon inequality (lower income group may be less carbon efficient and charged more over carbon pricing). Hence redistributive measure is nessecary to ensure public acceptance of carbon pricing policies	Taken into account. The inequility issue is one of the most important areas in the evaluation of policy instruments but this section is only for the emission impacts of policies. The Chapter 13 on the comprehensive evaluation of policy instruments might be the right place to touch on this issue. Included a footnote in the first page of this subsection: "This section only reviews emission impacts of policy instruments. Other important aspects such as equity and cost-effectiveness will be dealt with in Chapter 13 that is dedicated for the comprehensive evaluations of policies and measures."	Zhifu	Mi	University College London	United Kingdom (of Great Britain and Northern Ireland)
10373	95	14			This section is too heavily focused on carbon pricing policies; it should also consider how policies (that jay or mayu not have been motivated by climate change) in the area of innovation and technology have shifted baseline costs - especially in electricity generaiton, technology cooperation etc. Also, this section might be the place to consider the role of air quality measures in changing emission trends (or not), although I feel this ought to be brought in much earlier in the chapter (section 2.4).	Partially accepted. Evaluation of air quality measures in terms of emission impacts are added. With regards to technology, section 2.6 and Chapter 16 deal with technology policies in detail.	Reisinger	Andy	NZAGRC	New Zealand

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
17635	95	14			This is probably the relevant section in which to note the importance of national and international government, vis-à-vis my Exec sum comment (repeated here): Two key observations / references: As a driver, It surely is relevant to note that countries which had accepted legally binding targets under the Kyoto Protocol all complied: Shishlov, I., Morel, R., Bellassen, V. 2016. Compliance of the Parties to the Kyoto Protocol in the first commitment period. Climate Policy. doi:10.1080/14693062.2016.1164658 This evidence was not available for AR5 (compliance was only reported in 2014 and verified in 2015). I also commented on this in an extended Editorial, which pointed to evidence that this was not because the targets were too easy and didn't require substantive action (Michael Grubb (2016) Full legal compliance with the Kyoto Protocol's first commitment period – some lessons, Climate Policy, 16:6, 673-681, DOI: 10.1080/14693062.2016.1194005 It is striking in fact that 17 of the 18 countries for which you report "sustained emission reductions" (Fig 2.6) were industrialised country Parties to the Kyoto protocol, with legally binding emission reduction commitments, which they delivered. For a chapter entitled "emission trends and drivers" it seems very strange not to mention this as a likely major driver. Second, I think the wider spread of climate legislation as the pressures grew to globalize efforts also should feature more strongly: Gabriela Iacobuta, Navroz K. Dubash, Prabhat Upadhyaya, Mekdelawit Deribe & Niklas Höhne (2018) National climate change mitigation legislation, strategy and targets: a global update, Climate Policy, 18:9, 1114-1132, DOI: 10.1080/14693062.2018.1489772	Accepted. Included multiple sentences on this point.	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
24863	96	3	96	15	Indicate that the analysis does not take into consideration matters related to equity and justice	Accepted. Included a footnote in the first page of this subsection: "This section only reviews emission impacts of policy instruments. Other important aspects such as equity and cost-effectiveness will be dealt with in Chapter 13 that is dedicated for the comprehensive evaluations of policies and measures."	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
17637	96	2			See my comment to the section on Sectoral emission trends and drivers, concerning the UK example and how carbon pricing interacted with the other two policy pillars of efficiency and renewables.	Accepted. Included the UK example and an evaluation from this view with a reference.	Grubb	Michael	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
42655	97		97		The colors are hard to see/distinguish because the circles are so small, please try to use other symbols to show carbon gap intensity	Partially accepted. The graph is deleted.	Eyckmans	Johan	KU Leuven	Belgium
28351	97	2			Not sure how useful this figure is, it is not easy to read. Suggest to delete if not too significantly important	Accepted. The graphs are deleted	Chan	Hoy Yen	ASEAN Centre for Energy	Malaysia
28353	97	5			suggest using the same currency for GDP and carbon pricing	Noted. The graphs are deleted	Chan	Hoy Yen	ASEAN Centre for Energy	Malaysia
42657	98	3	98	4	openening sentence is very affirmative but most studies find a statistically significant but albeit small decrease it emissions that can be attributed to ETS. I suggest to phrase the opening more cautiously.	Rejected. It is true that the literature agrees on the emission reductions, though the magnitude of reduction varies.	Eyckmans	Johan	KU Leuven	Belgium
16017	98	3	98	5	In sentence: "carbon price associated with the EU ETS (Figure 2.44 Carbon intensity of GDP and carbon pricing gap in 2015.Figure 2.44)". Please re arrange the bracket.	Editorial. Corrected the error	Takarina	Noverita	Universitas Indonesia	Indonesia
16019	98	11	98	11	in sentence: "U ETS are estimated at 3.35 percent on average, or 0.45 percent…." Please changed the percent with %	Editorial. Well taken!	Takarina	Noverita	Universitas Indonesia	Indonesia
24865	98	3	98	27	Indicate that the analysis was implemented prior to the Paris Agreement and under a different EU ETS price enviroment compared to recent trends	Rejected. It is obvious from the references that the analyses are done before the Paris Agreement.	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
44489	98	38	98	38	"Effort Sharing Decision" lasts only until 2020, from 2021 on it will be covered by the "Effort Sharing Regulation", with the same architecture but different rules	Noted. The sentence has been changed.	Geden	Oliver	German Institute for International and Security Affairs	Germany
24867	98		99		Indicate that Table 2.9 is based on analysis implemented prior to the Paris Agreement and under a different EU ETS price enviroment compared to recent trends	Partially accepted. The table 2.9 is deleted.	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
16021	99	6	99	39	Please also provide researches where the policies are failed to reduce emissions/ the carbon policies are not effective in reducing emissions.	Accepted. The literatures on policies with no GHG reduction impacts are added.	Takarina	Noverita	Universitas Indonesia	Indonesia
6995	99	1			In column 1 "current study" should be substituted with the respective reference. In column 2 not only "Phase 1 years" are covered as the heading suggests.	Partially accepted. The table 2.9 is deleted.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
6997	99	8			There seems to be a contradiction, or at least a clarification is needed for: "ETS sectors significantly decrease their emissions relative to non-ETS sectors after the start of ETS, while no obvous impact on carbon intensity was identified after ETS started"	Noted. The paragraph is deleted.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
6999	99	19			The sentence starting in line 19 and ending in line 21 is unclear	Accepted. The explanation is streamlined for readability.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
7001	100	10	100	14	There seems to be a contradiction, or at least a clarification is needed for: "... A CO2 tax was not sufficient to result in a significant change in CO2 emissions.... A higher oil price was important in reducing national CO2 emissions"	Accepted. The explanation is streamlined for readability.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
38781	100	27	100	30	Can you clarify if these state-level policies reduced CO2 emissions of the state or at the national level? Also, is this reduction in CO2 emissions underestimated given that only a few states are included in national CO2 emission reduction calculations?	Taken into account. An explanation of 'average state-level annual emissions from the power sector' is added to make it clear wheter the reduction is at state or national level.	Reyes	Julian	Personal Capacity	United States of America
7007	100	30	100	33	The first of these two sentences is rather uninformative. Which kind of policy combinations and individual policies ?	Accepted. The uninformative sentence is deleted.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
2173	100	38	100	38	Please, replace "mortal" by "mortar".	Editorial. The sentence is removed for not being appropriate in this section.	Sanjuán	Miguel Angel	Technical University of Madrid	Spain
16207	100	3	101	16	For the subsection entitled “Sector-specific policies” consider including global militaries as an emissions sector, and including a brief treatment of these, for the sake of clarity and comprehensiveness that is appropriate for this type of document.	Partially accepted. Transferred the comment to the writers of the relevant section	Helman	Daniel	College of Micronesia-FSM	Micronesia, Federated States of
7003	100	23			How is efficiency defined? Carbon efficiency of GDP or value added or energy or something else?	Taken into account. The efficiency used here is the operational efficiency measured with Malmquist Index, in which power capacity, coal consumption and employee number are used as input variables and power generation as the output variables. An additional explanatory expression is added.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
7005	100	25			Which command and control regulations are specifically are referred to?	Noted. The command and control regulations here include emission standars, fines, supervision, environmental assessment system and production technology standards. Some examples are included in the text.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
24259	100	42			The three citations, i.e., (Ma and Cai 2018), (Ma et al. 2017), and (Lu, Cui, and Li 2015), can not be found in the reference list.	Partially accepted. The related paragraphs are removed for not being relevant here.	Zhifu	Mi	University College London	United Kingdom (of Great Britain and Northern Ireland)
7009	100	45			I do not understand the meaning of the sentence starting in line 45 and ending in line 47	Partially accepted. The related paragraphs are removed for not being relevant here.	Oberdabernig	Doris A.	World Trade Institute, University of Bern	Switzerland
30469	102	2	102	14	Could this be more substantial? Seems strange after all this work, and then the narrative is dominated by gaps in data afterward, so readers may simply dismiss the whole chapter in their heads, which is a shame, considering how important if not unsettling is this chapter.	Accepted. More subtantial remarks are added.	Cook	Lindsey	Quaker United Nations Office / Friends World Committee for Consultation (IPCC Observer)	Germany
37931	102	44	103	32	"Inequity" would be a better word here than "inequality" since you are stretching beyond income/wealth to discuss other aspects of social difference and impacts on emissions.	Will be taken care of	Perkins	Patricia	York University	Canada
2331	102	16	103	42	Some missing knowledge mentioned in the chapter does not appear in Section 2.10, e.g. p39 emission transfers among developping countries and South-South trade, p71 possibly distorted roles of renewables versus CSS in AIMs, and I would add analysis of the AFOLU sector and its trends	Will be taken care of	Martinerie	Patricia	CNRS	France
10375	102	16			It would be helpful if the gaps in knowledge could be anchored to the key conclusions - how and to what extent would closing those knowledge gaps help address issues that the key conclusions have grappled with but were unable to conclude? Many of the paras currently just say that "more research is needed" but it's not clear to what extent this is just the view of researchers working in this area - please demonstrate and prioritise the policy-relevance of those gaps relative to the key conclusions that the chapter has drawn.	Will be taken care of	Reisinger	Andy	NZAGRC	New Zealand

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Last Name	Reviewer First Name	Reviewer Affiliation	Reviewer Country
2591	103	7	103	7	"more evidences are needed" should read "more evidence is needed"	Will be taken care of	Czerniak	Michael	Atlas Copco - Edwards	United Kingdom (of Great Britain and Northern Ireland)
40121	103	20	103	22	"clearer understanding of the influence of these disruptive technologies (demand and supply side) on GHG emissions are elusive." Quantification of technology change and policy effect needs to be addressed through a clear framework	Will be taken care of	Soysa	Ramesh	Biomass Group & World Bank	Sri Lanka
40123	103	23	103	24	Assessments of carbon lockin forms such as residual carbon, carbon sequestration needs to be intergrated through a conclusive framework into the carbon accounting.	Will be taken care of	Soysa	Ramesh	Biomass Group & World Bank	Sri Lanka
2593	103	27	103	27	"more evidences are needed" should read "more evidence is needed"	Editorial. Well taken!	Czerniak	Michael	Atlas Copco - Edwards	United Kingdom (of Great Britain and Northern Ireland)
24869	103	27	103	31	Additional research should also take into account national circumstances and priorities	Accepted. Included ", taking into account national circumstances and priorities"	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
2595	103	37	103	38	"Digitalization of economy are often quoted as providing new opportunities, but the more knowledge and evidences are necessary." should be "Digitalization of the economy is often quoted as providing new opportunities, but more knowledge and evidence is needed."	Editorial	Czerniak	Michael	Atlas Copco - Edwards	United Kingdom (of Great Britain and Northern Ireland)
1971	111	43		46	The literature references (Ekholm et al. 2013a) and (Ekholm et al. 2013b) are the same reference. (I am one of the authors of the reference.) The right form of the reference is Ekholm, T., T. J. Lindroos, and I. Savolainen, 2013: Robustness of climate metrics under climate policy ambiguity. Environ. Sci. Policy, Vol. 31, p. 44-52. https://doi.org/10.1016/j.envsci.2013.03.006.	Editorial	Savolainen	Ilkka	Tech.Res.Ctr. of Finland VTT, emeritus research professor	Finland
24261	126	23			Two duplicated references.	Editorial	Zhifu	Mi	University College London	United Kingdom (of Great Britain and Northern Ireland)
20267	142	6	142	7	Based on consumer principles, there net CO2 emissions should be calculated in the consumer country's emissions, rather than the meaning of "transfer"in the expression, and these emissions are indeed emitted in developing countries geographically, which are not belong to territorial emission of developed countries, but the conclusion of "there is a net CO2 emission transfer from developing to developed countries via global trade" obviously ignors the statistical scope of consumer principle emissions and should not discussion trade embodied emissions from the perspective of producer principles.	Will be taken care of	shang	li	CAS shanghai advanced research institute	China
1101	298	1	298	42	Additional literature is available for the EU ETS, for other trading systems and for European carbon taxes. See references and summaries in Haites, Erik, Duan Maosheng, Kelly Sims Gallagher, Sharon Mascher, Easwaran Narassimhan, Kenneth R. Richards, and Masayo Wakabayashi, 2018. Experience with Carbon Taxes and Greenhouse Gas Emissions Trading Systems, Duke Environmental Law and Policy Forum, Fall 2018, 29(1), 109-182. Available at: https://scholarship.law.duke.edu/delpf/vol29/iss1/ and Metcalf, Gilbert, 2019. On the Economics of a Carbon Tax for the United States. Brookings Papers on Economic Activity, Spring 2019, 405-484. https://www.brookings.edu/bpea/search/	Noted	Haites	Erik	Margaree Consultants Inc.	Canada
1289					chapter 2 should take on board discussion about baseline. what is, is it policy as usual...a box could be useful. Check overlapping with chapter 3	Rejected for now - unclear questions, this is trend chapter.	BOSETTI	VALENTINA	BOCCONI -eiee	Italy
2283					The chapter is mostly focused on CO2 FFI emissions. However AFOLU emissions represent about 23% of total GHG emissions (IPCC SRCCL SPM section A.3) and could represent a key part of the solution by becoming a carbon sink. The SRCCL report could be used (and possibly updated) to better cover the AFOLU related GHG emissions.	Taken into account - AFOLU section covered in the chapter, espcially in trends section. There are rooms to address driver and other issue in AFOLU sector better. We will see.	Martinerie	Patricia	CNRS	France
2285					The term "FOLU" is systematically used between pages 4 and 24 while AFOLU is systematically used afterward, I did not understand why agriculture is excluded at the begining	Noted - due to data and info	Martinerie	Patricia	CNRS	France
2287					The strong focus on China cited more than 150 times, with two country-specific illustrations (Fig 2.13 and Table 2.3) may seem unfair. In contrast, Australia, the largest coal exporter, is mentioned only four times in the text before the bibliography. India also deserves a more specific analysis, for example in Section 2.4.1.3 Divers in Asian and developping Pacific countries, it is only quoted twice as "China and India"	Taken into account	Martinerie	Patricia	CNRS	France

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2289					In depth per country or groups of countries analysis is performed, but the role and behaviour of large multinational corporations id not analysed. Could this be performed ? Is more research work needed ?	Rejected	Martinerie	Patricia	CNRS	France
2291					I find interesting to compare the effects of various "1% increase" across the chapter. It looks like a simple analysis tool to be encouraged to evaluate mitigation options. Examples : p48 l7-8: a 1% increase in GDP leads to about 1% increase in CO2 emissions of countries ; p50 l35: in OECD countries a 1% increase in environmental tax revenue per capita reduces carbon emissions by 0.03% ; p55 l35 A 1% increase in 'environmentalism' – defined as the "environmental voting record of the state's Congressional delegation" (Dietz et al. 2015) – leads to a 0.45% decrease in emissions ; p96 l11 one percentage point increase in the carbon pricing gap is associated with a 0.016 (0.019) percent increase in the carbon intensity of GDP in 2015	Noted	Martinerie	Patricia	CNRS	France
5963					The chapter misses to define forest fires among major sources of carbon dioxide emissions, they were particularly important in 2019 by emitting about 1 billion tons of CO2 (the exact data to be cross-checked). Although the forest fires constitute a non-anthropogenic source of emissions, in many ways they are provoked either by human negligence (eg. case of Siberian fires in 2019) or by human late reaction to solve the issue (eg. Australian fires). Hence, there is an indirect human impact which needs to be outlined	Noted	Andrei	Belyi	University of Eastern Finland, Centre for Climate Change, Energy and Environmental Law	Estonia
9373					Figure 2.36	Editorial	PISELLO	ANNA LAURA	DEPARTMENT OF ENGINEERING - UNIVERSITY OF PERUGIA, ITALY	Italy
9375					is not clearly visible. Low quality and small size wording	Editorial	PISELLO	ANNA LAURA	DEPARTMENT OF ENGINEERING - UNIVERSITY OF PERUGIA, ITALY	Italy
13463					The hypothesis regarding SLCF emissions are missing, how the level of air pollutiion control is considered in the SSP, what are the key methodological uncertainties…. What is the robustness of maximum available technology and its spread assumed in high air pollution control? How air pollution control drives SLCF emissions compared with climate mitigation? Such aspects need to be detailed to allow a proper discussion and use of SLCF emissions and to better caracterize the benfit/tradeoffs between air quality and climate.	Taken into account	Szopa	Sophie	Commissariat à l'Energie Atomique et aux Energies Alternatives	France
20273					As a driver for recycling, waste segregation and collection of waste will increase transport miles in a trade off with waste emission benefits (Steele & Dumble 2006). For the adoption of a transition policy, models and best practice (WRAP 2020) that have been in development, consider the co-benefits from logistics and travel planning for construction wastes and multimodal transfer encouraging change to lower emission options (Tfl 2020). Transition towards net zero emission targets requires the adaption of freight vehicles away from fossil fuels to renewable fuels such as electricity, hydrogen, used cooking oils, methane generated from anaerobic digestion of food wastes or sewerage as set out for London in Greater London Authority (2018) with supporting case studies and strategies. References: Steele S., Dumble P. (2006). Waste freight strategy developments in London, Bestuffs II workshop, Zurich, April. A presentation outlining the challenges and opportunities for waste transport in London over the next 20 years accessed 1/2/2020 at . http://www.bestufs.net/download/Workshops/BESTUFS_II/Zurich_Mar06/BESTUFS_Zurich_Mar06_Steele_TransportForLondon.pdf TfL (2020). Freight, website site accessed 1/2/2020 at https://tfl.gov.uk/corporate/publications-and-reports/freight. WRAP (2020). Good practice guidance, website accessed 1/2/2020 at http://www.wrap.org.uk/category/what-we-offer/good-practice-guidance Greater London Authority (2018). London Environment Strategy, Greater London Authority, ISBN 978-1-84781-694-8, pp233 accessed 2/1/2018 at https://www.london.gov.uk/sites/default/files/london_environment_strategy_0.pdf	Noted	Dumble	Paul	Paul's Environmt Lentd	United Kingdom (of Great Britain and Northern Ireland)
24809					Present GHG emission trends from 1970 to 2018	Rejected	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
24813					Replace "low-carbon technologies" with "low-emission technologies"	Noted	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria

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24815					Replace "fossil fuel CO2" with "energy-related CO2"	Noted	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
24817					Replace "FFI" with "energy-related"	Noted	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
24819					Present direct and indirect energy-related emissions	Noted- unclear context	Kaditi	Eleni	Organization of the Petroleum Exporting Countries (OPEC)	Austria
25515					Please take care not to use value-judgement terms such as 'important', 'significant' and also prescriptive terms such as 'need' and must'. Some readers will interpret these statements as policy prescriptive.	Accepted	Connors	Sarah	IPCC WGI TSU	France
25549					As a reader who isnt familiar with all the topics being discussed in your chapter, it might help many Exectutive Summaries to include subheadings to cluster the statements by topic or overarching chapter themes.	Noted	Connors	Sarah	IPCC WGI TSU	France
26549					p. 8 Are you sure that the figure 2-1 brings something to the subject???	Accepted	Livet	Frédéric	CNRS-France	France
26551					p. 26 I have a problem with the figures. You choose a set of countries that give significantly different results, but you should add France, because this country has very good results in CO2 emissions and in kg CO2/$ (e and f): -4.57KgCO2/inhabitant (half of Germany) -1.115KgCO2/$ (half of Germany) you obtain these results from: https://data.worldbank.org/country/france?view=chart It is important to show how results can vary depending in the energy mix! If you do not like France, choose Sweden, they are still better (but they have large hydroelectricity, it is a natural advantage)..	Noted	Livet	Frédéric	CNRS-France	France
26553					p. 26. There is something missing on the the energy intensity of the economy. I have a figure, which I attach, from: https://ourworldindata.org/energy Where I have added France and China. This figure has the advantage of showing the historical progress (China) and the excellent results of France. I want to insist that we must not only mention percentages, but also the present performances.	Noted	Livet	Frédéric	CNRS-France	France
28805					Figs 2.34 and 2.33. There is no reference to what is driving CDR inertia to accompany the notes regarding the required pace and scale of deployment e.g., governance vacuum, absence of policy measure including re markets to drive uptake, limited research and innovation investment and social reticence/acceptance issues.	Noted - we will look into it- technology section	Rouse	Paul	Carnegie Climate Governance Initiative	United Kingdom (of Great Britain and Northern Ireland)
29505					Figure 2.9: the top and bottom left panels go well together in explaining TCBE and its change over time. Meanwhile the bottom right panel looks at the change in CBE/capita without showing (in the same figure, perhaps in the form of an additional panel) the actual CBE/capita for these countries. Adding such a panel (actual CBE/capita) is an important part of the story in order to emphasise equity. As things stand, the interpretation of the lower right panel could be extended from “India has the highest change in CBE/capita” to “India has the highest CBE/capita”.	Noted	Al Khourdajie	Alaa	IPCC WGIII TSU	United Kingdom (of Great Britain and Northern Ireland)
33115					The summary is extended and excellent	Noted	Alam	Edris	Rabdan Acadmey	United Arab Emirates
42839					A major driver of foscil fuel consumption are the enourmous foscil fuel subsidies equivalent to 6% of global GDP and rising (IMF Working Paper, 2019/89 - Global Fossil Fuel Subsidies Remain Large: An Update Based on Country-Level Estimates). Eliminating these subsidies would reduce GHG emissions by 28% - this is a major issue nd is missing from this Chapter.	Noted	MAJOR	Mark	Partnership on Sustainable Low Carbon Transport	Spain
43917					when talking about how long the fictive carbon budget would last for which climate target it would need to be made very clear how large the following temperature overshoot would be and for how long it would persist after the climate target is surpassed. Otherwise this information would be misleading for non-experts and suggestive of a safe time window with no consecutive challenges.	Noted	and Elvira Poloczanska	Hans Poertner	Alfred-Wegener-Institut	Germany

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43923					The role of direct hydrogen production and synthetic fuels has not been (sufficiently) considered in this chapter.	Rejected- too generak comment, we are not looking at particular technolgies here	and Elvira Poloczanska	Hans Poertner	Alfred-Wegener-Institut	Germany
45721					In the whole section of this chapter, it would be better to handle more detailed analysis on the effect of industrial change on emission. As you can see on Figure 2 .20 [Placeholder for decomposition of emissions from developed countries] on pp2-51, Energy/GDP is the largest factor which effects emission trends in OECD countries. Energy/GDP trends illustrates not only energy conservation efforts but also the industrial structural change within the country. For examples, major factor of decoupling in OECD countries would be industrial changes which were led by industrial strategy context, especially the shift from energy intensive industry to high value added industries. Therefore, it would be better to include more detailed surveys of effect by industrial change in this chapter.	Noted	Ogawa	Junko	The Institute of Energy Economics, Japan	Japan
47941					ES : it could be valuable to report emission trends in units specific to each GHG (not just CO2-eq which depends on choices of metrics, here using the AR5 approach, while other approaches such as GWP* have been developed; WGI is reporting the contribution of each GHG to total radiative forcing and is not using CO2-equivalent).	Noted-will be discussed internally	Masson-Delmotte	Valérie	CEA, IPSL/LSCE	France
47943					ES : the translation of the remaining carbon budgets into remaining years at the current level of emissions does not seem the most adequate approach, as illustrated by public debates following the publication of SR15. Moreover, different approaches using different methods (SR15 = hybrid between GMST and GSAT, 50th for 1.5°C) give different results, so full traceability is needed. Coordination with WGI is needed due to a change in approach (use of GSAT) + revised climate response assessment (TCRE).	Noted- will be discussed internally	Masson-Delmotte	Valérie	CEA, IPSL/LSCE	France
47945					ES : the issue of co-emissions of SLCF (with a net cooling effect of aerosols) is not mentioned, needed for coherency / WGI / zero emission commitment etc. I hope that there will be enough literature before the cut off dates to allow WGIII to address the near and long term implications of the COVID19 pandemic.	Noted- will be discussed internally	Masson-Delmotte	Valérie	CEA, IPSL/LSCE	France
47947					ES : "scenarios in line with the Paris Agreement" is vague and requires a clear definition	Noted- to be discussed	Masson-Delmotte	Valérie	CEA, IPSL/LSCE	France
47949					ES : when addressing consumption based emissions, please clarify what is considered (net effect of trade, international travel?). What about the consumption based footprint including all GHG?	Noted - to be discussed	Masson-Delmotte	Valérie	CEA, IPSL/LSCE	France
47951					ES: when decoupling is mentioned, is it about national emissions or the consumption based one, is it for CO2 only and what about the net effect of all GHG emissions?	Noted - to be discussed	Masson-Delmotte	Valérie	CEA, IPSL/LSCE	France
47953					ES : explain changes before/after 2011 for improvements in carbon intensity	Noted - to be discussed	Masson-Delmotte	Valérie	CEA, IPSL/LSCE	France
47955					ES : "Since 2012, fossil CO2 emission growth has accelerated" : please check how the "acceleration" is measured (2019 seems different) (statistical significance in term of acceleration + duration of analysis).	Noted - to be discussed	Masson-Delmotte	Valérie	CEA, IPSL/LSCE	France
47957					ES : What is meant by "at the global level, renewable energy does not yet significantly decarbonize energy systems" = does it mean that what is observed is an addition but not a substitution of fossil fuels?	Noted - to be discussed	Masson-Delmotte	Valérie	CEA, IPSL/LSCE	France
47959					ES : There seems to be a contradiction between the statement that "affluence" is a driver of emission increase, while "eradicating extreme poverty" has negligible implications for emission growth.	Noted - to be discussed	Masson-Delmotte	Valérie	CEA, IPSL/LSCE	France
47961					ES : is there a historical perspective in the underlying chapter assessment of energy system changes? I have read several analyses by historians who challenge the use of the term "transition" to describe changes over the past centuries (they stress the fact that the use of coal added to an increased use of wood and did not replace it, etc). They suggest an increased amount in material and energy use rather than transitions in the past.	Noted - to be discussed	Masson-Delmotte	Valérie	CEA, IPSL/LSCE	France
47963					ES : there seems to be a bias in the description of per capita top emitters. What is the respective weight of different income categories worldwide and the weight of not just the wealthiest but also the developed countries middle classes?	Noted - to be discussed	Masson-Delmotte	Valérie	CEA, IPSL/LSCE	France
47965					ES: there is a strong focus on CO2 and energy. What about other GHG and the link with the AFOLU sector?	Noted - to be discussed	Masson-Delmotte	Valérie	CEA, IPSL/LSCE	France
47969					It is surprising that the chapter only allocates 3 pages on behavioral choices and lifestyles in relationship to emission trends and drivers.	Noted - to be discussed	Masson-Delmotte	Valérie	CEA, IPSL/LSCE	France
47971					For committed emissions (section 2.8), coordination is needed with WGI to facilitate integration between geophysical and infrastructure commitments	Noted - to be discussed	Masson-Delmotte	Valérie	CEA, IPSL/LSCE	France

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47973					Section 2.9: what about subnational climate policies (eg. cities, regions…)?	Noted - to be discussed	Masson-Delmotte	Valérie	CEA, IPSL/LSCE	France
48099					ES : is there a link between climate change and adaptation as a driver of GHG emissions (e.g. heating / cooling demands related to cold /warm season temperature and humidity trends)? This is not mentioned.	Noted - to be discussed	Masson-Delmotte	Valérie	CEA, IPSL/LSCE	France
48101					ES: the role of population growth is only marginally addressed in the chapter ES, could it be more elaborate?	Noted - to be discussed	Masson-Delmotte	Valérie	CEA, IPSL/LSCE	France
48103					The ES of chapter 1 is written as if we were not living in a world where the impacts of climate change are already affecting land and sea ecosystems, people and livelihoods. Could it be posible to anchor the framing of mitigation in today's context (2020) of a changing climate and growing severity of impacts?	Noted - to be discussed	Masson-Delmotte	Valérie	CEA, IPSL/LSCE	France